



CONSERVATION PLAN FOR SEA TURTLES, MARINE MAMMALS AND THE SHORTNOSE STURGEON IN MARYLAND

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PREFACE

This conservation plan is intended to serve as a guide that identifies and delineates those actions believed to be necessary to manage and conserve sea turtles, marine mammals and the shortnose sturgeon in Maryland waters. Some of the tasks listed are already underway and their inclusion represents their importance as well as recognition of progress towards that goal. The plan represents a cooperative effort among federal and state agencies and private organizations to identify, delineate and implement those steps necessary to conserve these species in Maryland. Due to the diversity of information concerning the species included in this project, the conservation plan was essentially divided into two documents, one dealing with marine mammals and sea turtles collectively and the other with the shortnose sturgeon. Although the two documents duplicate some information, particularly regarding protective legislation and conservation authorities, the overlap is minimal. The concepts the author presents were based in part upon the suggestions and expertise of individuals from a variety of agencies and organizations within and outside of Maryland. The following individuals were involved in the development of this conservation plan:

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MARINE MAMMALS AND SEA TURTLES

INTRODUCTION

There are 27 species of marine mammals known to utilize Maryland waters. Eight of these species are listed or proposed as endangered or threatened under the Endangered Species Act (ESA) of 1973 and one is listed as depleted under the Marine Mammal Protection Act (MMPA) of 1972. All 4 species of sea turtles that visit Maryland waters are listed as either threatened (loggerhead and green sea turtles) or endangered (Kemp's ridley and leatherback sea turtles).

Section 4(f) of the ESA directs responsible agencies to develop and implement recovery plans for endangered species, unless such a plan will not promote the conservation of a species. Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect the species. Plans are prepared by the United State Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) and sometimes with the assistance of recovery teams, contractors, state agencies, and others.

Recovery plans exist for the conservation of United States populations of most endangered marine mammals and all sea turtles. Several plans, such as those for the sperm, sei, and fin whales, are still in development. However, the Federal plans do not address the specific needs of these species while utilizing Maryland waters. Marine mammals and sea turtles are subject to varying pressures depending on their geographic location. Environmental conditions, commercial fishing activity, boat traffic, harassment levels, and habitat degradation are among the many factors that may vary from state to state. Thus, in order to contribute to the overall recovery of a species, a state conservation plan is necessary to identify the specific needs of these species and to manage and conserve their populations while they utilize Maryland waters.

FUNDING

The development of this conservation plan is funded through Section 6 of the ESA. In general, Section 6 provides for cooperative agreements between the Federal government (specifically the USFWS and NMFS) and states to share the responsibility of conservation within that state. States that enter into a Section 6 agreement must establish and maintain an adequate and active program for the conservation of threatened and endangered species.

The state of Maryland applied for a Section 6 agreement in 1992. Having successfully demonstrated the key elements (state laws, existing conservation programs, enforcement authority, and supervisory staff expertise) germane to the protection and conservation of endangered and threatened species, the agreement was finalized in 1998. At this time, the state was awarded funds through Section 6 of the ESA to develop a conservation plan for marine mammals, sea turtles, and the shortnose sturgeon.

CONSERVATION EFFORTS

Historical Efforts

Prior to 1990, the National Museum of Natural History (NMNH) of the Smithsonian Institution was primarily responsible for the conservation and study of marine mammals in Maryland. The Smithsonian Institution has long had an interest in marine mammals, starting with the hiring of Spencer Fullerton Baird in 1850 as assistant secretary with the responsibility of the directorship of the United States National Museum. Baird became the second secretary of the Smithsonian Institution and was instrumental in forming the United States Fish Commission in 1871, of which he became the first director. The Fish Commission went through a variety of name changes, from the Bureau of Commercial Fisheries up through its current title, the National Marine Fisheries Service. The Commission has always had an interest in marine mammals fostered by the interests of its first director. The current Marine Mammal

Program of the Smithsonian maintains an excellent working relationship with the NMFS, resulting in numerous additions to the marine mammal collection.

The first "curator" of marine mammals was Frederick W. True. He was hired as a librarian and acting curator of mammals in the United States National Museum in 1881 and was very active in exhibits and research, mainly dealing with both living and fossil marine mammals. In the years since True, the Smithsonian has employed several curators with a variety of interests including fossil marine mammals, whale conservation, the formation of the International Whaling Commission (IWC), and the biology of odontocetes such as the genus *Kogia*.

In 1972, the NMNH established the Marine Mammal Program, a cooperative research program that focuses on whales, dolphins, porpoises, seals, sea lions, and manatees. Working closely with Federal, state, and local governments, Museum staff study stranded animals as well as those incidentally taken by commercial fisheries. These observations provided previously unknown information on population size, distribution, eating habits, and reproductive patterns of many species of marine mammals. The data are maintained in the Cetacean Distributional Database, and include the collections of the NMNH (the largest marine mammal collection in the world with more than 5,500 specimens of cetaceans, 3,100 specimens of pinnipeds, and 370 specimens of sirenians) and distributional records of cetaceans from many other sources, including museums and stranding programs. The database contains information such as species, date of stranding, location, sex, length, and nature of occurrence. The Marine Mammal Program also maintains a number of ancillary collections in addition to its primary collections, the largest of which is a compilation of notes and photographs. The Museum periodically hosts harbor porpoise training workshops to demonstrate proper necropsy procedures and assessment of human interaction such as net marks from fisheries. The Museum's extensive marine mammal collection is available to outside researchers from around the world for collaborative studies involving evolution, genetics, and morphometrics.

Current Efforts

Maryland Department of Natural Resources

The Maryland Department of Natural Resources (DNR), created as a state agency in 1969, is responsible for overseeing the management and wise use of the living and natural resources of the Chesapeake Bay and its tributaries. The resources of the Maryland portion of the watershed include its state forests and parks, fisheries, wildlife, and the recreation of citizens engaged in boating, fishing, hunting, and other outdoor enjoyment of natural resources. The mission of DNR is "For today and tomorrow the Department of Natural Resources inspires people to enjoy and live in harmony with their environment, and to protect what makes Maryland unique—our treasured Chesapeake Bay, our diverse landscapes and our living and natural resources."

The Maryland DNR has many field offices located throughout the state. The U.S. Bureau of Commercial Fisheries established the Oxford Laboratory in 1960 for the primary purpose of investigating oyster diseases that struck the Chesapeake and Delaware Bays in the late 1950s. In 1987 it became the Cooperative Oxford Laboratory (COL), a joint research and monitoring facility of the Maryland DNR and the NMFS of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Scientists at the COL investigate health problems of fish, shellfish, and other aquatic life in the Chesapeake Bay and along the Atlantic Coast. They also collaborate with scientists nationally and internationally to improve understanding of aquatic animal health and develop management strategies to prevent and mitigate diseases. New techniques for classifying and mapping critical reef habitats in Chesapeake Bay have been recently developed at the COL. These methods are now being applied to Maryland's oyster restoration efforts.

The COL also participates in the national Marine Mammal and Sea Turtle Stranding Network, investigating strandings of rare and endangered animals in Maryland, and sharing information, samples, and exper-

tise with other institutions and coastal states. Prior to 1990, Maryland did not have a consistent stranding program nor did its neighboring states. Stranding responses were conducted on an as needed basis and there was some confusion as to what agency had authority over the stranding programs and who was responsible for responding. Before 1990, coverage for the Chesapeake Bay was shared by the National Aquarium in Baltimore (NAIB), the Virginia Institute of Marine Science (VIMS), the NMNH and the Maryland DNR. There was no hotline to report strandings and no formalized stranding network. Federal funds for stranding response were not available to Maryland and Delaware and limited funds were offered to Virginia for sea turtle research.

The Maryland DNR recognized the need to establish contingency plans for stranding events. As a result, a series of organizational meetings were held in 1990 to develop a unified stranding network for the tristate region and to train lead personnel in proper specimen handling. The first meeting was held on December 14, 1990. The goal of the meeting was to establish a framework for interactions between Maryland, Virginia, Delaware, and other Federal or private organizations that would be involved in stranding response. Education, training, data collection, sample collection, carcass disposal, and the need for holding facilities and rehabilitation were addressed. It was agreed that each state would develop a standard operating procedure for stranding response. Seven training sessions were conducted from November 19, 1990 to March 27, 1991 at Virginia Tech, the Smithsonian, the NAIB, and Assateague Island. The sessions dealt with necropsy techniques, sample collection, data collection, live animal transport, live animal restraint, hand feeding, administration of drugs, physical examinations, and emergency treatments of live animals.

Clarity was needed within Maryland as to what agencies had authority and responsibility for the marine mammal stranding program. The Maryland DNR was identified as the lead agency for the state with regard to marine mammal stranding response. The department had the administrative support, legislative authority, and logistical teams to make the network succeed. In addition, the NAIB was designated as a key institutional agency for rescue and rehabilitation of live stranded animals through a Letter of Authorization (LOA) from the NMFS. With this framework in place, the network was established. The Maryland Marine Mammal and Sea Turtle Stranding Network is administered jointly by the Maryland DNR at COL and by the NAIB. COL stranding personnel respond to dead stranded animals while the NAIB responds to live animals.

The Maryland stranding program at the COL is a primarily unfunded stranding network for threatened and endangered sea turtles and marine mammals, covering the northern Chesapeake Bay and the Atlantic Coast of the Delmarva Peninsula. The network has three key components: 1) stranding response, 2) research support, and 3) outreach and education. The stranding program provides response to all stranded marine mammals and sea turtles including endangered humpback whales, Kemp=s ridley and leatherback sea turtles, threatened loggerhead sea turtles, and harbor porpoises and bottlenose dolphins. The network collaborates with several scientific, governmental, and educational organizations, including the NAIB for live strandings, the states of Delaware and Virginia for coastal strandings, and the Smithsonian Institution for collecting and archiving scientific samples.

Seventeen species of marine mammals and four species of sea turtles have stranded dead in Maryland waters since the inception of the stranding network in the fall of 1990. On average 37 animals strand each year. The stranding network collects species identification, stranding location and life history (morphometric) data and investigates causes of death, especially to assess human interaction from boat strikes, bullet wounds, fisheries interactions, and entanglement or ingestion of marine debris. This information is recorded on standardized data sheets provided by the NMFS. Necropsies are conducted on all animals and samples are collected for histopathology, microbiology, toxicology, and virology from fresh carcasses. The network fills sample requests from researchers around the country and investigates or cooperates with other investigators in disease and toxicological studies. In cases of live strandings, the COL assists the NAIB with capture and transportation when needed. The program contributes to state research interests as

well as national concerns through the dissemination of database information and distribution of parts catalogued and processed from stranded animals. Significant efforts are made towards conservation and recovery of these species through extensive outreach and educational programs in which staff deliver oral presentations to civic, school and other groups and organizations, participate in public outreach events, and publish printed information for distribution.

National Aquarium in Baltimore

Conservation is an integral component of the mission of the NAIB. The Conservation Program promotes three initiatives: Chesapeake Bay, Biodiversity, and Ocean Health. The Ocean Health Initiative is focused at global and regional scales (D. Schofield, NAIB, personal communication).

On a global scale, the Aquarium works with marine mammal stranding and ocean health issues through the work of Dr. Joseph Geraci, the Aquarium's Senior Director of Biological Programs. During the past 20 years, the frequency and severity of marine mammal dieoffs appear to have increased, raising concerns that these events are a consequence of human pressure on the marine environment. The causes of the dieoffs included viruses, toxic algal blooms, and climatic events leading to widespread starvation. Dr. Geraci has participated in the investigations of many of these dieoffs, working on behalf of the United States government, foreign governments, and international agencies. His teams were among the first to demonstrate the devastating potential of viral illness and algal toxins to marine mammal populations. These studies are ongoing and currently involve the participation of the NAIB.

On a regional scale, the Aquarium supports a Marine Animal Rescue Program (MARP), which is the cornerstone of the Ocean Health Initiative. This program works to rescue, rehabilitate, and release marine mammals and sea turtles that become stranded in the mid-Atlantic region. The mission statement of the program is "Committed to the humane care and treatment of injured, ill, or out of habitat marine mammals and sea turtles, the Marine Animal Rescue Program of the National Aquarium in Baltimore supports the development and dissemination of new knowledge in an effort to support the conservation of wild species." Volunteers are the backbone of this program. They assist with animal care and are involved in outreach programs providing the public with a first hand account of the care of stranded animals. From 1991 to 2000 this program rescued 142 animals from the beaches of the Northeastern United Sates, of which 33 were successfully returned to the wild. A great deal has been learned from these animals, including many firsts in the scientific field. For example, Aquarium scientists discovered a previously unknown parasite from the blowhole of a pygmy sperm whale, performed the first successful cataract surgery on a sea turtle, and collected data on the range of hooded seals through the use of satellite telemetry.

Locally, the NAIB maintains nine bottlenose dolphins (*Tursiops truncatus*), seven harbor seals (*Phoca vitulina*), and two gray seals (*Haliecheorus grypus*) within its marine mammal collection. Conservation and educational presentations featuring these animals are presented daily to the public and highlight marine mammal behavior, conservation issues, laws and regulations, and action items for the public to take home for ocean health stewardship. Interactive exhibits within the marine mammal pavilion interpret various conservation issues and provide hands-on information on the biology and behavior of a variety of marine mammal species.

The Aquarium also organizes and participates in various public outreach events throughout the state to raise awareness about marine mammal and sea turtle issues. One such event, the annual Coastal Dolphin Count, occurs in July along the Atlantic coast from New Jersey to Florida. Volunteers count bottlenose dolphins along the Maryland coast for two hours on a Saturday morning to obtain an estimation of abundance. In July 2000, the Aquarium organized and cosponsored a Marine Mammal Awareness Symposium held in Ocean City, Maryland. Other sponsors included the U.S. Coast Guard, the Maryland DNR, the NMFS, and the National Park Service. Recreational boaters, marine owners, jet ski rental vendors, charter

boat captains, ecotourism directors, commercial fishermen and the general public were invited to learn about stranded animal response programs in Maryland and marine mammal behavior, harassment, and law enforcement issues. The Aquarium plans to make the symposium an annual event to raise public awareness of marine mammal issues in Maryland waters.

JURISDICTION AND REGULATIONS

Protective Legislation

Endangered Species Act (16 USC §1531-1544)

At the Federal level, efforts to protect endangered and threatened species began with the passage of the Endangered Species Preservation Act of 1966. The Endangered Species Conservation Act of 1969 strengthened these initial provisions but still had several weaknesses; it contained no prohibition on "taking" of endangered species, had no significant protection for habitat, and did little to address threats to individual populations that were endangered or threatened (Baur et al. 1999). Congress realized that a more comprehensive Federal effort was needed to protect and conserve species facing extinction. As a result, the Endangered Species Conservation Act was replaced by the much-strengthened Endangered Species Act in 1973. The Endangered Species Act (ESA) has as its main purpose to conserve the nation's natural heritage for the enjoyment and benefit of current and future generations. The ESA provides for the conservation of species that are in danger of extinction throughout all or a significant portion of their range and the habitats on which they depend. It also prohibits the taking of an endangered species. Take is defined broadly and includes harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capturing or attempting to engage in any of these activities.

An individual or organization may petition to have a species considered for listing under the Act as endangered or threatened. The listing of a species qualifies it for increased protective measures. Generally, the USFWS coordinates ESA activities for terrestrial and freshwater species, while the NMFS is responsible for marine and anadromous species. With the submission of a petition, the agencies must either reject the petition or accept it and conduct a status review of the species. The status review is initiated with solicitation of public information relevant to the species.

A species must be listed if it is threatened or endangered due to any of the following five factors:

- 1) present or threatened destruction, modification, or curtailment of its habitat or range;
- 2) over utilization for commercial, recreational, scientific, or educational purposes;
- 3) disease or predation;
- 4) inadequacy of existing regulatory mechanisms; or
- 5) other natural or manmade factors affecting its continuance or existence.

Once a species is listed, Section 4 of the ESA requires the development and implementation of recovery conservation plans to improve a species' status. Several species of whales (including humpback, northern right and blue whales), all five species of sea turtles, the North Pacific fur seal, the Hawaiian monk seal, and the Steller sea lion have final recovery plans and several more are under development (fin, sei, and sperm whales). Concurrent with the listing decision, critical habitat believed necessary for the continued survival of a species is designated. In addition, Section 7 of the ESA requires all Federal agencies to consult with the NMFS or the USFWS concerning any potential effects of their actions on a listed species. Ongoing consultation with other Federal agencies must minimize or mitigate potential impacts. The NMFS reviews non-Federal activities that may affect listed species and issues Section 10 permits for incidental take.

The ESA provides fairly comprehensive protection by the USFWS and the NMFS for threatened and endangered species. In addition to Section 4, which allows for the recovery planning process, Section 6 provides for cooperative agreements between the Federal government and states to share the responsibility of conservation within that state. Agreements are established in states that develop and maintain

conservation programs for endangered and threatened species. In Maryland, the DNR has a Section 6 agreement with the NMFS to develop this conservation plan for sea turtles, marine mammals and the shortnose sturgeon in the state.

Marine Mammal Protection Act (16 USC §1361-1421h)

The Marine Mammal Protection Act (MMPA) of 1972 is the other principal legislative act governing activities that involve marine mammals in the wild. It is perhaps the most comprehensive marine mammal conservation and management legislation in the world. In passing the MMPA, Congress found that certain species may be in decline as a result of man's activities; that such species should not be permitted to diminish below their optimum sustainable population level and cease a functioning element of their ecosystem; that measures should be taken to protect habitat and replenish any species which falls below its OSP level; that there is inadequate knowledge of the ecology and population dynamics of marine mammals; and that marine mammals are a great international, aesthetic, recreational and economic resource.

The MMPA vested marine mammal management authority in the Federal Government. Under this law the Secretary of Congress, through the NMFS, is responsible for ensuring the protection of cetaceans (whales, dolphins and porpoises) and pinnipeds (except walruses) and the Secretary of the Interior, through the U.S. Geological Service and the USFWS, is responsible for walruses, sea otters, polar bears, manatees, and dugongs. The MMPA provides that management authority, on a species-by-species basis, can be returned to states that adopt conservation and management programs consistent with the purposes and policies of the Act. The MMPA also established the Marine Mammal Commission, a scientific advisory board that collects data and gives expert advice on marine mammals, and the Marine Mammal Health and Stranding Response Program, which includes the marine mammal stranding networks found in every coastal state in the United States.

The MMPA established a moratorium, with certain exceptions, on the taking (which is defined to mean "to harass, hunt, capture or kill, or attempt to harass, hunt, capture, or kill") of marine mammals in United States waters and by United States citizens on the high seas, and on the importation of marine mammals and marine mammal products into the United States. The MMPA moratorium on taking does not apply to any Native American, Aleut, or Eskimo who resides in Alaska or dwells on the coasts of the North Pacific or Arctic Oceans, if such taking is for subsistence purposes or for creating and selling Native handicrafts and clothing, and is not wasteful. The MMPA also provides that the moratorium on taking can be waived for specific purposes if the taking will not disadvantage the affected species or stock. Under a permit system, the act also allows the taking and importing of marine mammals for scientific research, education, public display, incidental catches in commercial fishing operations, or to enhance the survival or recovery of a species or stock.

The MMPA defines optimum sustainable population (OSP) as "the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the optimum carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." NMFS regulations have further defined OSP as "a population size which falls within a range from [the carrying capacity of the] ecosystem to the population level that results in maximum net productivity." Once a species has been designated as depleted, a conservation plan is developed to guide research and management actions to restore the health of that species.

The MMPA was most recently reauthorized in 1994; these amendments were by far the most comprehensive to date. They established a new regime to govern the taking of marine mammals incidental to commercial fisheries. This new regime includes the preparation of annual stock assessments for all marine mammals in waters under United States jurisdiction, the development and implementation of take reduc-

tion plans for stocks that may be reduced or have fallen below their OSP levels due to commercial fisheries interactions, and studies of pinniped-fisheries interactions.

Since the 1994 amendments became law, the NMFS has published several regulations to implement requirements under the Act. These include the general authorization for scientific research, the development of new management regions for governing the incidental taking of marine mammals in commercial fisheries, the prohibition of intentional lethal take in commercial fisheries, and a final rule prohibiting vessels from approaching closer than 100 yards to humpback whales in Hawaii. In 1995, the NMFS authorized the intentional lethal taking of individually identifiable California sea lions that are adversely affecting the continued existence of a steelhead trout population at Ballard Locks, Washington.

Magnuson Fishery Conservation and Management Act (16 USC §1801-1882)

The Magnuson Fishery Conservation and Management Act of 1976 (MFCMA; Pub. L. 94-265, as amended; renamed the Magnuson-Stevens Fishery Conservation and Management Act when amended on October 11, 1996), was passed in response to United States concerns that foreign fleets were overexploiting America's fishery resources and that international agreements were not conserving fish stocks (Young et al. 1993). The purpose of the Act was to address heavy foreign fishing, promote the development of a domestic fleet, and link the fishing community more directly to the management process. The Act established an United States Exclusive Economic Zone (EEZ) that ranges between 3 and 200 miles offshore in which the NMFS has exclusive authority for fisheries regulations and management. Under provisions of this Act, eight Regional Fishery Management Councils were established for the New England, mid-Atlantic, South Atlantic, Caribbean, Gulf of Mexico, Pacific, Western Pacific, and North Pacific regions to manage the living marine resources within these areas. Each council is composed of state officials with fishery management responsibility, the regional administrators of the NMFS, and individuals appointed by the Secretary of Commerce who are knowledgeable regarding the conservation and management of fishery resources of the geographical area in question. The eight Councils prepare fishery management plans (FMPs) for those fisheries, both commercial and recreational, which they determine to require active Federal management. In developing these FMPs the Councils use the most recent scientific assessments of the ecosystems involved, with special consideration of the requirements of marine mammals, sea turtles, and other protected resources. An environmental assessment or environmental impact statement is prepared for every FMP submitted. After public hearings on these plans, revised FMPs and draft regulations are submitted to the Secretary of Commerce for approval. Regulations are published in the Federal Register to implement approved plans.

The Sustainable Fisheries Act, enacted in 1996, reauthorized and amended the Magnuson-Stevens Act. The amendments emphasized the sustainability of the nation's fisheries and included changes to existing national standards for fishery management. The new standards require that fisheries be managed at maximum sustainable levels, that bycatch be reduced, and that new approaches be taken in habitat conservation. This includes the delineation of essential fish habitat (EFH), which is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH is added to FMPs via the Council's amendment process. This directive to identify and protect essential habitats is likely to have indirect benefits for other marine species, such as marine mammals and sea turtles, which inhabit such areas (Baur et al. 1999).

Lacey Act (16 USC §3371-3378)

Originally passed in 1900, the Lacey Act prohibits import, export, transportation, sale, receipt, acquisition, or purchase of fish, wildlife, or plants that are taken, possessed, transported, or sold in violation of any Federal, state, tribal, or foreign law. The Act has become a vital tool in efforts to control smuggling and trade of illegally taken fish, wildlife, and plants. The 1981 amendments to the Act were designed to strengthen Federal laws and improve Federal assistance to states and foreign governments in enforcement of fish and wildlife laws. The law covers all plants, fish, and wildlife, and their parts or products, pro-

tected by the Convention on International Trade in Endangered Species, and those protected by state law. The Lacey Act also regulates the transportation of live wildlife, requiring that animals in the United States be transported under humane and healthful conditions. However, it does not apply to interstate shipment of any fish, wildlife, or plant legally taken if the shipment is en route to a state in which the fish, wildlife, or plant may be legally possessed. The Secretary of the Interior is authorized to designate those wildlife species considered injurious to humans, agriculture, wildlife resources, or otherwise, and prohibit their importation into the United States.

Pursuant to this Act, the Secretary of Commerce may make available rewards to individuals who provide information leading to arrests, criminal convictions, civil penalties, or the forfeitures of property. Individuals convicted of violating the Lacey Act may be sentenced up to \$100,000 and one year in jail for misdemeanors and up to \$250,000 and five years in jail for felony violations. Fines for organizations in violation of the Lacey Act are up to \$250,000 for misdemeanors and \$500,000 for felony violations. In addition, officers enforcing the Act are authorized to inspect vessels, vehicles, aircraft, packages, crates, and containers upon arrival in or prior to departure from the United Sates and to seize all vessels, vehicles, aircraft, and other equipment used to aid in criminal violations of this Act.

NMFS special agents enforce the Lacey Act against foreign-flagged vessels that fish illegally in the EEZs of South Pacific Island countries and import the fish into Guam and American Samoa. In addition, the NMFS enforces this Act against United States fishermen who operate illegally in foreign waters such as the Bahamas. NMFS agents work cooperatively with state natural resource officers to apprehend poachers who take contaminated shellfish from closed state waters and subsequently ship those illegal products in interstate commerce.

Maryland Endangered Species Act

The Maryland Endangered Species Act of 1971 (Article 66C, Section 125, Annotated Code of Maryland) became the first piece of state legislation protecting endangered species in Maryland. The law prohibited the taking, transportation, possession, processing, or sale within the state of Maryland of any wildlife appearing on the Federal lists of endangered, foreign, or native fish and wildlife. It also mandated the Secretary of the DNR to develop a list of fish and wildlife deemed to be threatened with statewide extinction and provided full protection for those species. The first state list of endangered species was promulgated in 1972 and consisted of twenty-one species. The Maryland Endangered Species Act was revised in 1973. The revision consisted mostly of a clarification of language; the substance of the original act was retained.

In 1975 the Maryland Nongame and Endangered Species Conservation Act (Natural Resources Article, §10-2A, Annotated Code of Maryland) was passed, replacing the revised Endangered Species Act of 1973. This act mandated the investigation, management, and protection of both nongame wildlife and threatened and endangered species of wildlife and plants. It also established a consultation process whereby all state cabinet level departments were to consult with the Secretary of Natural Resources to further programs for threatened or endangered species and minimize the effects of their actions which might jeopardize the existence of these species. The Nongame and Endangered Species Conservation Act is the primary state law that allows and governs the listing of endangered species in Maryland. The Act is supported by regulations (Code of Maryland Regulations or COMAR, 08.03.08) that contain the official State Threatened and Endangered Species list. In addition, all Federally listed species are automatically listed in Maryland (Nat. Res. Art., §4-2A-04a and §10-2A-04a). Secondarily, the DNR's Fisheries Service maintains an official list of game and commercial fish species that are designated as threatened or endangered in Maryland (COMAR 08.02.12) through the Maryland Endangered Species of Fish Conservation Act of 1975 (Nat. Res. Art., §4-2A, Annotated Code of Maryland). This act governs the regulation and care of threatened and endangered fish species in Maryland through many of the same actions as the Nongame and Endangered Species Conservation Act. Violations of the Nongame and Endangered Conservation Species Act or the Endangered Species of Fish Conservation Act are misdemeanors punishable by fines up to \$1000 and/or imprisonment of one year. Under the Fish Conservation Act violations may also result in the seizure of fishing licenses and confiscation of fish, gear, equipment, and vessels used in fishing activity (COMAR 08.02.12.02).

FEDERAL CONSERVATION AUTHORITIES

National Marine Fisheries Service and United States Fish and Wildlife Service

The Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) has responsibility for protection of the majority of wild marine mammals. The NMFS is responsible for the protection and management of whales, dolphins, porpoises, seals, and sea lions. The MMPA also vests responsibility for marine mammals to the Department of the Interior, Fish and Wildlife Service (USFWS). The USFWS maintains jurisdiction over the remaining marine mammal species, which are polar bears, manatees, dugongs, walruses, and sea otters. These two Federal agencies have also delineated responsibility for sea turtles. The USFWS has jurisdiction over sea turtles when on land or in fresh water and the NMFS has jurisdiction over sea turtles when in the marine habitat. Together, the two agencies bear the responsibility for conservation of marine mammals and sea turtles through direct legislative mandates and partnerships with Federal, state and private organizations, the fisheries industry, and the general public (Driscoll 1999).

Marine Mammal Commission

Established under Title II of the MMPA, the Marine Mammal Commission (MMC) is an independent agency of the Executive Branch. It consists of three members appointed by the President, with the advice and consent of the Senate. The MMC is a scientific advisory board that collects data and gives expert advice on marine mammals. It is charged with developing, reviewing, and making recommendations on the actions and policies of all Federal agencies with respect to marine mammal protection and conservation and with carrying out a research program (MMC 1998). This includes reviewing the status of marine mammal stocks and human methods of take and making recommendations regarding species to be listed as endangered or threatened under the ESA or international marine mammal policies (Baur et al. 1999). The Commission is required to consult with its nine-member Committee of Scientific Advisors on Marine Mammals when making recommendations. Both the USFWS and the NMFS have administrative jurisdiction over parts of the MMPA, but they must consult with the MMC before actions are taken.

STATE CONSERVATION AUTHORITIES

Maryland Department of Natural Resources

At the state level, the Maryland DNR oversees the management and use of the living and natural resources of the Chesapeake Bay and its tributaries. The DNR has broad responsibility to conserve threatened and endangered species. As described earlier, the two statutes which govern the regulation and care of these species are the Maryland Endangered Species of Fish Conservation and the Maryland Nongame and Endangered Species Conservation Act. In these acts "conserve" is defined as the means to use all methods and procedures for the purpose of increasing the number of individuals within species or populations up to the optimum carrying capacity of their habitat and maintaining these levels. These methods and procedures include activities associated with resource management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation, including the protection of species or populations as well as regulated taking.

The laws also direct the DNR to determine, using specified factors, whether any species of fish or wildlife normally occurring within the state is threatened or endangered. These factors include present and threatened destruction of a species' habitat or range, overutilization for commercial, sporting, scientific, educational or other purposes, and disease or predation (Nat. Res. Article, §4-2A-04 and §10-2A-04, Annotated Code of Maryland). The DNR is authorized to adopt rules and regulations to provide for the conservation of endangered and threatened species, to establish programs, including the acquisition of land or aquatic

habitat, necessary for the conservation of listed species, and to enter into agreements with Federal and state agencies, Maryland political subdivisions, and individuals to conserve listed species. All state agencies are directed to utilize their authorities in furtherance of the Acts and carry out programs for the conservation of threatened and endangered species.

ENFORCEMENT AUTHORITIES

The following is an overview of law enforcement agencies that are empowered with enforcing marine mammal and sea turtle regulations in Maryland.

National Marine Fisheries Service

The National Marine Fisheries Service Office for Law Enforcement is a component of the Department of Commerce, National Oceanic and Atmospheric Administration. The primary mission of the Office is the protection and conservation of the Nation's living marine resources. Their responsibilities include: protection, conservation, and management of the fishery resources within the 200 mile United States EEZ under the authority of the Magnuson-Stevens Fishery Conservation and Management Act; protection of marine mammals and threatened or endangered species under the MMPA and the ESA; extended jurisdiction beyond the EEZ, to include both highly migratory and anadromous species; and international responsibilities in the enforcement of the Convention on International Trade in Endangered Species (CITES) and other international resource related crimes investigated under the authority of the Lacey Act.

The NMFS approach to ecosystem protection and management includes Community Oriented Policing and Problem Solving (COPPS). COPPS promotes voluntary compliance through constituent communication, public awareness, education, investigation, and prosecution of criminal and civil violators, seizure of contraband and illegally possessed property, and collection of information on criminal activities involving resource-related crimes.

The NMFS enforces a variety of Federal laws and regulations, including the Lacey Act, Magnuson-Stevens Fishery Conservation and Management Act, the MMPA, the ESA and the National Marine Sanctuaries Act. The Office of Law Enforcement has lead a variety of investigations related to their mission to protect and conserve the Nation's living marine resources. For example, in April 1999 a NOAA enforcement team found the owner and operator of a Texas shrimp trawler in violation of sea turtle protection laws. They found that one of the nets on board the vessel did not have the required turtle excluder device (TED) installed while another net with a TED did not meet minimum turtle escape requirements and had captured an endangered Kemp's ridley sea turtle (NOAA 1999a). The owner and operator of the shrimp trawl were each fined \$5,000 for the violations. In July 1999 a Panama City boat rental company and its operator were charged by NOAA with five counts of harassing or attempting to harass wild dolphins by feeding the animals minnows during a parasail boat trip. These acts, which are in violation of the MMPA, resulted in a \$4,500 fine for both the rental company and its boat operator and an order to post a Federal "no dolphin feeding" sign on the grounds of the facility (NMFS 1998b). Regionally, marine mammal and sea turtle stranding response personnel have interacted with local enforcement officers on several occasions, including two chain of custody cases involving seals that were rescued from Damneck, Virginia and Assateague Island, Maryland, that had both been shot (D. Schofield, NAIB, personal communication). In addition, the NMFS Office of Enforcement has aligned with stranding network partners on stranding, rescue, and assessment endeavors in Maryland when it was felt that law enforcement issues might arise.

National Park Service - Assateague Island National Seashore

The National Park Service (NPS) was established by the NPS Organic Act (16 USC §1), which provided authorization to hire law enforcement officers and protect resources within its jurisdiction. A variety of Federal laws give the Secretary of the Interior management responsibilities that are delegated to the NPS. These include the Clean Air Act, the ESA, National Environmental Policy Act, and the Wilderness

Act of 1964. The Code of Federal Regulations (36 CFR) is the primary tool that is routinely used by the NPS for enforcement issues, as it specifically lists what regulations can be enforced by park rangers. In addition, the NPS will utilize an array of other Federal laws for enforcement issues including the MMPA, the ESA, and the Lacey Act. The Secretary of the Interior is authorized to designate officers of the Department of the Interior to maintain law and order and protect persons and property within areas of the NPS. An officer is authorized to carry firearms, make arrests, to execute warrants, and to conduct investigations as prescribed by law and policy. In most parks, depending on the type of jurisdiction (exclusive, partial, concurrent, etc.) NPS officers can enforce Federal laws and assimilate state law when no applicable Federal law or regulation exists. In addition, depending on the type of jurisdiction, state officers can enforce state laws and regulations in national parks.

The Secretary of the Interior can create and publish rules and regulations deemed necessary for the proper use and management of the parks, monuments, and reservations under the jurisdiction of the NPS. A person convicted of violating the rules and regulations of the NPS can be punished by a fine as provided by the law or by imprisonment. Most regulations have an approved collateral fine attached to them, one that is recommended by each individual park and approved by the Federal district court judge. Fines may range from \$25.00 for feeding the park wildlife to as much as several hundred dollars. The sentencing Reform Act of 1993 allows for law fines up to \$5,000 and or 6 months in jail for each CFR violation.

Assateague Island National Seashore (AINS), located in Maryland and Virginia, is managed by the NPS. NPS has ownership and jurisdiction of the seashore which "shall comprise the area within Assateague Island and the small marsh islands adjacent thereto, together with the adjacent water areas not more than one-half mile beyond the mean high waterline of the land portions" (16 USC §459f). The seashore is administered for the general purposes of public outdoor recreation, including the conservation of natural features contributing to the public enjoyment, as well as the conservation and management of natural resources. The Secretary of the Interior is authorized to enter into cooperative agreements with local, state, and Federal agencies and with educational institutions to coordinate research designed to ensure full protection of the natural and cultural resources of the seashore. These efforts must be consistent with the purposes for which the seashore was established as well as other applicable laws. Assateague Island consists of Assateague Island State Park, managed by the Maryland DNR, and Assateague Island National Seashore, managed by NPS. Assateague Island has concurrent jurisdiction, meaning that state officers routinely patrol park waters and enforce state laws, and in some cases enforce Federal laws and regulations. Park rangers at AINS are authorized to enforce legislation protecting marine mammals and sea turtles, although other Federal agencies, such as the NMFS and the United States Coast Guard, have primary jurisdiction in enforcing these laws. AINS rangers routinely identify strandings, notify the appropriate resource management entity (the Maryland DNR for dead strandings and NAIB for live strandings), educate boaters about marine mammal and sea turtle protection, investigate any violation of applicable laws, and take law enforcement action when a violation is observed. For example, in 1998 a camper was fined for removing a harbor seal from the beach and taking it to a campsite. Under the direction of the NAIB, the seal was placed back at the water's edge, where it swam off (D. Schofield, NAIB, personal communication).

United States Coast Guard

The United States Coast Guard (USCG) is the nation's leading maritime law enforcement agency and has broad, multi-faceted jurisdictional authority. The specific statutory authority for the Coast Guard Law Enforcement mission is given in 14 USC §2, "The Coast Guard shall enforce or assist in the enforcement of all applicable laws on, under, and over the high seas and waters subject to the jurisdiction of the United States." In addition, 14 USC §89 provides the authority for USCG active duty commissioned, warrant, and petty officers to enforce applicable United States laws. It also authorizes Coast Guard personnel to enforce Federal law on waters subject to United States jurisdiction and in international waters, as well as on all vessels subject to United States jurisdiction, including United States foreign and stateless vessels.

Protecting the United States' EEZ and key areas of the high seas is an important mission for the Coast Guard. The Coast Guard enforces fisheries laws at sea, as tasked by the Magnuson-Stevens Fisheries Conservation and Management Act. One of their fisheries priorities is protecting the United States EEZ from foreign encroachment. The United States EEZ is the largest in the world, containing 3.3 million square miles of ocean and 90,000 miles of coastline. Foreign fishers operating illegally in this area are, effectively, stealing resources from the United States, and fisheries managers have no way of measuring or accounting for this loss. A second priority involves enforcing domestic fisheries law. United States domestic fisheries support a \$24 billion dollar industry. To ensure the sustainability of these fisheries, FMPs are developed by regional Fisheries Management Councils, each of which has a non-voting Coast Guard member. The USCG is responsible for enforcing these FMPs at sea, in conjunction with NMFS enforcement ashore. In addition to FMP enforcement, the USCG enforces laws to protect marine mammals and endangered species. The third and final priority involves international fisheries agreements. Realizing that fish do not recognize national boundaries, the Coast Guard works closely with the Department of State to develop and enforce international fisheries agreements. Most notably, the Coast Guard enforces the United Nations High Seas Driftnet Moratorium in the North Pacific, where illegal driftnetters may catch United States origin salmon.

The USCG Station in Ocean City, Maryland is the primary Coast Guard facility that the Maryland stranding network interacts with on a regular basis. They are a sub-command under the USCG group Eastern Shore that is based in Chincoteague, Virginia. The stranding network has also cooperated with USCG Station St. Inigoes on the Potomac River and the USCG station Curtis Bay in Baltimore's Inner Harbor. There are several other smaller installations that fall under the above commands that act as primary contacts. The USCG groups mentioned enforce the MMPA and ESA and act as law enforcement technicians for other Federal regulatory branches.

The USCG boarded more than 9,000 United States fishing vessels in 1999 to ensure compliance with Federal fisheries regulations, Endangered Species Act requirements, and fishing vessel safety regulations. The Coast Guard detected 416 fisheries violations and over 3,000 safety violations on these boardings. In recent memory the USCG has not cited anyone in Maryland for marine mammal or sea turtle harassment violations but have issued many warnings (D. Schofield, NAIB, personal communication).

Maryland Natural Resources Police

Maryland's Natural Resources Police (NRP), a unit of the DNR, is the only agency mandated by state law specifically to enforce conservation and boating laws. It is Maryland's oldest state law enforcement agency and one of the oldest conservation law enforcement agencies in the country. Throughout Maryland, the NRP force has full police powers. It is commissioned to enforce the natural resources laws of the state (Nat. Res. Art., Title 1, Subtitle 2, Annotated Code of Maryland) including the Maryland Nongame and Endangered Species Conservation Act and the Maryland Endangered Species of Fish Conservation Act. The agency also acts as a technician for the NMFS. NRP officers protect the safety and welfare of Marylanders enjoying the outdoors and enforce state laws and regulations on boating, commercial seafood harvesting, sport fishing, waterways pollution, wildlife conservation, and general criminal laws. Several of these laws include regulations (with certain exceptions) regarding the illegal possession, transportation, delivering, exportation, processing, selling, or shipping of any threatened or endangered species of wildlife (including marine mammals and sea turtles), fish or plant within or from the state. Officers inspect seafood processing houses, trucks carrying seafood cargo, and boats for violations of conservation laws and make arrests and issue warnings to violators. The NRP also investigates boating accidents and reports them to the USCG.

This law agency plays an important role in the Maryland Marine Mammal and Sea Turtle Stranding Network. NRP has a 24-Hour Hotline (1-800-628-9944) to report marine mammal and sea turtle strandings or sightings in Maryland. Officers take reports from callers and contact stranding network personnel

to respond to the situation. The hotline is critical for a timely and efficient response to strandings in Maryland.

COLLABORATING AGENCIES

In addition to the mandated conservation programs of the Federal, state, and institutional agencies discussed above, several other organizations contribute to marine mammal and sea turtle conservation in Maryland and should be recognized. Summarized below are the major organizations and partners who actively participate in Maryland's marine mammal and sea turtle conservation programs, particularly through cooperative efforts related to the Maryland Marine Mammal and Sea Turtle Stranding Network.

National Aquarium in Baltimore, Baltimore, MD

The collaborative conservation efforts of the National Aquarium in Baltimore were previously discussed in the Current Conservation Effort section of this document.

National Museum of Natural History, Smithsonian Institution, Washington, D.C.

The collaborative conservation efforts of the National Museum of Natural History were previously discussed in the Historical Conservation Effort section of this document.

Environmental Protection Agency (EPA), Philadelphia, PA

The Environmental Protection Agency (EPA) conducts aerial surveys from Atlantic City, New Jersey to Corolla, North Carolina from May through September each year. These aerial surveys provide an opportunity to document marine mammal and sea turtle distribution in inshore waters along the mid-Atlantic United States. Data collected during the surveys consist of the location and number of animals (including non-marine mammal and sea turtle species) and the presence of recreational and commercial fishing activity, recreational boaters (boats, jet skis), algal blooms, and oil spills. This data can be used to estimate abundance of marine mammals and sea turtles along the coast and identify any potential problem areas related to commercial and recreational activities and environmental conditions.

Armed Forces Institute of Pathology, Washington, D.C.

The Armed Forces Institute of Pathology (AFIP) is a tri-service agency of the Department of Defense with a threefold mission of consultation, education, and research. Within the Institute, there are 22 subspecialty departments with more than 120 pathologists. Since its inception over a century ago, the AFIP has been a world leader in pathological diagnosis and research. The Department of Veterinary Pathology, a discipline within AFIP, is involved extensively in marine mammal pathology. The AFIP is the single largest repository of pathologic material from marine mammals. Acquired information is archived and catalogued in a marine mammal database established in 1994 that contains information dating back to the 1800s. The database includes information regarding parasitic, bacterial, and viral infections as well as neoplasia and congenital conditions observed in captive and free-ranging marine mammals. A wide variety of species are represented in the database, including cetaceans, pinnipeds, mustelids (otters), and sirenians. Through a cooperative agreement established by the NMFS in 1992, the Maryland Marine Mammal and Sea Turtle Stranding Network at COL sends tissue samples, such as liver, kidney, stomach, lung, and heart, collected from fresh stranded marine mammals and sea turtles to AFIP for histopathological analysis. Veterinary staff from the Department of Veterinary Pathology analyze the tissues and generate a report for each submitted case, which is sent to the stranding coordinator at the COL. This data is also entered in AFIP's marine mammal database.

Maryland Department of Agriculture, Animal Health Diagnostic Laboratory, College Park, MD

Target organs, including liver, kidney, brain, spleen, and lung, and anomalous tissues (e.g., lesions) from fresh stranded animals are sampled using mini-tip culturettes and submitted to the Maryland Department of Agriculture for microbial analysis. Through a cooperative agreement established in 1991, Dr.

Ana Baya, a microbiologist at MDA, analyzes the samples and sends the results to the stranding coordinator at the COL.

National Marine Mammal Tissue Bank, Gaithersburg, MD

The National Marine Mammal Tissue Bank was established in 1989 by the NMFS's Office of Protected Resources to provide protocols and techniques for the long-term storage of tissues from marine mammals for retrospective contaminant analyses (MMC 1998). The Bank is maintained as part of the National Biomonitoring Specimen Bank at the National Institute of Standards and Technology. Tissues are collected from specific indicator species (Atlantic bottlenose dolphins, Atlantic white-sided dolphins, pilot whales, harbor porpoises), mass stranded animals, and animals from mortality events (such as the bottlenose dolphin dieoff along the mid-Atlantic coast of the United States in 1987-88). The contaminants present in the tissues may be good indicators of the types and levels of pollutants present in coastal marine ecosystems. Archived tissues provide a standard for comparison with tissues collected from future mortality events. In addition, a serum bank and long-term storage of tissues for histopathological analysis are being developed.

Patuxent River Naval Air Station, Natural Resources Branch, MD

The Naval Air Station (NAS) stretches across approximately 8.5 miles of shoreline at the mouth of the Patuxent River, overlooking the Chesapeake Bay. The base supports naval aviation operations by researching, developing, testing, and evaluating aircraft, aircraft components, and related products. The facilities are also used by foreign governments, academic institutions, and private industry for similar projects. The Natural Resources Branch falls within the Public Works Department of the Air Station and is responsible for all land and wildlife management programs aboard the NAS. The Natural Resources Branch conducts many day-to-day activities that ensure the safe and efficient operation of the airfield as well as the protection of ecological resources. For example, Natural Resources staff conduct surveys of waterfowl, raptors, and shorebirds and provide arrival dates and peak concentrations to the station's Bird Aircraft Strike Hazard (BASH) reduction team to ensure aviation safety at the airfield. Deer population counts are conducted throughout the summer and the numbers are used to calculate target deer harvest numbers for the fall deer season. Natural Resources staff teach hunter education courses, which include information on weapons qualifications and hunting regulations. Ongoing surveys are conducted to identify and monitor populations of threatened and endangered plant and animal species, submerged aquatic vegetation, fish, small mammals, insects, and other invertebrates. The Natural Resources Branch has established cooperative research efforts with the USFWS, the Maryland DNR, universities, and local conservation groups to aid in meeting the stewardship goals and obligations of the NAS. Natural Resources staff participate in sea turtle necropsy training workshops and provide sea turtle stranding response in southern Maryland (in areas within close proximity to the base) when requested by the stranding network. Staff conduct necropsies, collect samples, and report findings to the stranding coordinator at the COL.

Calvert Marine Museum, Solomons, MD

The Calvert Marine Museum is a public, non-profit, educational, regionally oriented museum dedicated to the collection, preservation, research, and interpretation of the culture and natural history of southern Maryland. The Museum is located in Solomons, Maryland, on the western shore of the Chesapeake Bay. Several employees and volunteers of the Museum have attended training workshops on sea turtle biology and necropsy techniques and provide additional stranding response support in southern Maryland when needed.

Point Lookout State Park, Scotland, MD

Point Lookout State Park is located on the southern tip of St. Mary's County, at the junction of the Potomac River and the Chesapeake Bay. It is managed by the Maryland DNR Forest and Park Service. The park is historically important as the site of a Civil War prison, which housed more than 52,000 Con-

federate soldiers during the war. Several employees of Point Lookout State Park have attended training workshops on sea turtle biology and necropsy techniques and provide additional stranding response support in southern Maryland when needed.

SEA TURTLES AND MARINE MAMMALS IN MARYLAND WATERS

Sea Turtles

There are seven species of sea turtles found throughout the world, five of which occur along the United States Atlantic coast and in the Gulf of Mexico. These species are the loggerhead, leatherback, Kemp's ridley, green and hawksbill sea turtles. The green sea turtle has only been recorded twice in Maryland and the Atlantic hawksbill has never been documented in Maryland waters. The three remaining species, the loggerhead, leatherback, and Kemp's ridley sea turtles, regularly utilize Maryland's Chesapeake Bay and Atlantic Coast and are described below. Since the inception of the Maryland Marine Mammal and Sea Turtle Stranding Network in 1990, 213 dead (representing four species) and seven live (representing two species) sea turtles have stranded in Maryland waters (see Appendix I). The Maryland Stranding Network has also assisted neighboring states, such as Delaware and Virginia, with numerous sea turtle strandings.

Loggerhead Sea Turtle, Caretta caretta

Species Description

Adult and sub-adult loggerheads, *Caretta caretta*, have an elongate red-brown carapace that is often covered with barnacles, and cream-yellow plastron (Dodd 1988; NMFS & USFWS 1991). The dorsal scales of the head and appendages are reddish-brown or yellowish chestnut and become yellow towards the margins (flanks) and ventrally (Ernst et al. 1994; Carr 1952). There are two pairs of prefrontal scales and commonly one inter-prefrontal scale between the eyes. Typically, the carapace has five central or vertebral scutes, five costal scutes on either side of the central scutes, a precentral scute that is in contact with the first costal scute on each side, and eleven or twelve pairs of marginal scutes (NMFS& USFWS 1991a; Marquez 1990). Ventrally, there are three pairs of poreless inframarginal scutes on the bridge between the carapace and the plastron (NMFS & USFWS 1995).

A typical adult loggerhead has a carapace length of 85 to 100 cm and weighs about 135 kg, but these numbers can vary depending on geographical location (Ernst et al. 1994). Adult loggerheads in the southeastern United States have a mean straight carapace length (scl) of 92 cm and weigh approximately 113 kg. In other locations, such as Colombia and Greece, adults are somewhat smaller (NMFS & USFWS 1991). Although there have been reports of loggerheads weighing as much as 450 kg (Brongersma 1972; Pritchard and Trebbau 1984) they rarely exceed 122 cm scl and 227 kg (National Research Council 1990). In Maryland waters stranded loggerhead carapace lengths range from 48.9 to 132 cm (scl, notch to tip). Hatchlings, which range in color from light brown to black (NMFS & USFWS 1995), have a mean weight of about 20 g and a mean length of about 4.5 mm scl (Ernst et al. 1994).

Distribution

Caretta caretta is widely distributed in tropical, subtropical, and temperate waters around the world. They inhabit coastal, estuarine, and continental shelf waters of the Atlantic, Pacific, and Indian Oceans and the Caribbean and Mediterranean seas (Dodd 1988; Ernst et al. 1994). In the western Atlantic, loggerheads range as far north as Newfoundland and as far south as Argentina and Chile (Pritchard 1979). They are the most abundant sea turtle in Maryland waters, and have stranded as far north as Hart Miller Island, Baltimore County in the Chesapeake Bay and along the Maryland coast (see Appendix I).

Life History

The major nesting areas for loggerheads have been described as "antitropical," indicating that most of the nests occur in areas north of the Tropic of Cancer or south of the Tropic of Capricorn (Pritchard 1979). However, there are some nesting sites in the tropics, including Masirah Island, Oman, which was once believed to be the most important breeding ground for loggerheads in the world, with as many as 30,000 females nesting each year (Marquez 1990). In the United States, nesting occurs from Florida to New Jersey, although nesting north of Virginia Beach, Virginia, is sparse (Brandner 1983; Graham 1973; Pritchard 1979). Only three nests have been documented in Maryland in the last three decades. The first nest was in Ocean City in 1979 (Graham 1973), and the other two in the summer of 1999. One of these nests was located in Ocean City and the other on AINS. Both nests were relocated to the north end of Assateague Island, but neither nest was viable.

In the southeastern United States the incubation period for loggerhead eggs ranges from approximately 49 to 76 days (nest temperature is inversely correlated with the duration of incubation; Dodd 1988). After hatching, the hatchlings leave the beach and swim directly offshore in a "swimming frenzy," which can last two or three days and takes them about 22 to 28 kilometers offshore (Carr 1986; Dodd 1988). The hatchlings enter the Gulf Stream system of the North Atlantic Ocean and find food and refuge within drifting mats of *Sargassum* (Carr 1986, 1987). The turtles may make repeated transatlantic crossings in the north Atlantic gyre over a period of four or five years or until reaching a straight carapace length of about 40 to 50 cm (Carr 1986, 1987; NRC 1990). At this point they leave the pelagic habitat and migrate into inshore and estuarine waters of the eastern United States, the Gulf of Mexico, and the Bahamas, and begin the subadult or juvenile stage (Carr 1987; NMFS &USFWS 1991a).

Subadult loggerheads enter the Chesapeake Bay during the late spring and early summer (Lutcavage and Musick 1985) to forage on a variety of food items, notably the horseshoe crab, *Limulus polyphemus* (Klinger and Musick 1995; Mortimer 1995). As many as 5,000 to 10,000 loggerheads may inhabit the Bay each summer, feeding along channels near river mouths and drifting passively with the tide within a relatively limited home range (Musick and Limpus 1997). The turtles migrate out of the Bay from late September to early November as water temperatures drop (Klinger and Musick 1995) and travel south along the coast to points beyond Cape Hatteras, North Carolina (Musick and Limpus 1997). Most overwinter off the coast of North Carolina at the edge of the Gulf Stream, while others spend the winter along the coast of Florida (Musick and Limpus 1997) or enter the Gulf Stream and travel north (Keinath et al. 1989). As the turtles reach sexually maturity (between 12 and 30 years of age) they become migratory for the purpose of breeding (NMFS & USFWS 1991; NRC 1990). Adult loggerheads may travel several hundred kilometers to distant nesting beaches in the region of their birth and then return with high fidelity to the same juvenile foraging sites (Musick and Limpus 1997).

The list of food items eaten by loggerheads is lengthy and includes invertebrates from eight phyla (Dodd 1988). Subadult and adult loggerheads feed primarily on a wide variety of benthic invertebrates, including gastropod and pelecypod molluscs and decapod crustaceans (NMFS & USFWS 1991). Juveniles favor coelenterates, particularly jellyfish and cephalopod molluscs (which are also taken by larger turtles), and hatchlings evidently ingest macroplankton associated with drift lines. Snails, fragments of crustaceans, *Sargassum*, jellyfish, and algae have also been found in the gut contents of hatchlings in South Africa and the southeastern United States (NMFS & USFWS 1991; Dodd 1988).

Status

Loggerhead sea turtle populations have declined worldwide as the result of coastal development, which threatens nesting habitat and populations, and commercial fisheries and pollution, which pose significant threats in the marine environment. In 1978 the loggerhead was listed as threatened by the USFWS under the Endangered Species Act of 1973 (43 FR 1978). The Federal status was adopted by the Maryland DNR in 1980 and the loggerhead was added to the state endangered and threatened species list (COMAR 08.03.08.07).

Leatherback Sea Turtle, Dermochelys coriacea

Species Description

The leatherback, *Dermochelys coriacea*, is the largest living turtle in the world and is so distinctive it is in a separate taxonomic family, the Dermochelyidae (NMFS & USFWS 1995). While other sea turtles have bony plates covered with keratinized scutes on the carapace, the shell of a leatherback is covered with a continuous layer of smooth skin that has a rubber-like or leathery texture (Marquez 1990). The carapace, which is about 4 cm thick, primarily consists of firm oil-saturated connective tissue that is raised into seven longitudinal ridges (NMFS & USFWS 1992). The carapace, head, and limbs are typically brown to black in color, with small white to yellowish blotches or spots present (Ernst and Barbour 1989). Spotting becomes very dense laterally and on the ventral surface, giving the plastron a mottled appearance. Unlike the carapace, the plastron of the leatherback is very soft (Pritchard 1979). The front flippers are extremely long compared to other sea turtles, and usually equal or exceed half the length of the carapace (Marquez 1990; NMFS & USFWS 1992). The leatherback also differs from other sea turtles in that both sets of flippers lack claws (Pritchard 1979). Hatchlings are predominately black dorsally with mottled plastrons and the skin and shell are covered with small polygonal scales, which are shed within a couple of months of hatching (Ernst and Barbour 1989; Pritchard 1979).

Adult leatherbacks typically reach a straight carapace length of 155 to 170 cm and an average weight of approximately 360 kg, but can weigh as much as 600 kg (NMFS & USFWS 1992; Pritchard 1979). The largest leatherback on record stranded on the coast of Wales in 1988 and weighed 916 kg (Morgan 1989). In Maryland waters, stranded leatherback carapace length ranges from 119 to 199 cm (scl, notch to tip). The size and weight of hatchlings varies between nesting sites. The average size ranges from 51 to 68 mm and the weight from 37 to 49 g (Marquez 1990). In the United States Virgin Islands, hatchlings have an average length of approximately 61 mm scl and a weight of 46 g (Eckert et al. 1984).

Distribution

D. coriacea is highly migratory and the most widely distributed of all the reptiles (NMFS & USFWS 1995), ranging from tropical and temperate oceans to subpolar waters such as the Barents Sea (Marquez 1990). They are believed to be the most pelagic of all sea turtles, and may only enter coastal waters to reproduce and forage (Hendrickson 1980; Mortimer 1995). Leatherbacks are found in tropical waters of the Atlantic, Pacific, and Indian Oceans, where the majority of their nesting sites are located. However, they have also been recorded in the higher and lower latitudes of these oceans (Ernst et al. 1994). In the western Atlantic, leatherbacks occur as far north as Baffin Island (Shoop 1980) and as far south as Mar del Plata, Argentina (Carr 1952). The first record of a leatherback in the United States was a specimen caught in the Chesapeake Bay in 1811 (Carr 1952). They have stranded in the Chesapeake Bay as far north as Kent Island and Chester River Beach, both in Queen Anne's county, and along the Maryland coast. Leatherbacks may be considered rare in Maryland waters (see Appendix I).

Life History

The major nesting areas for leatherbacks occur circumglobally in the tropics, with the biggest nesting aggregation (over 80,000 nests per year) on the West Coast of Mexico (Marquez 1990; NMFS & USFWS 1992). In the western North Atlantic, nesting occurs along the coast of northern South America, Mexico, Central America, and the Caribbean Islands. Only the beaches of French Guiana, Surinam, and Costa Rica can be considered major nesting areas (Ernst et al. 1994). The United States Caribbean Islands and Puerto Rico support only minor nesting aggregations, but they represent the largest nesting colonies of leatherbacks in the United States (NMFS & USFWS 1992, 1995). Some nesting occurs along the Gulf of Mexico and the southeastern United States, particularly on the Atlantic coast of Florida, but nest density is usually lower than in the Caribbean and Puerto Rico (NMFS & USFWS 1992, 1995). Females seem to prefer high-energy beaches with a steep ascent and an unobstructed, deep-water access (Marquez 1990; NRC 1990).

In the southeastern United States and the Caribbean the incubation period for leatherback eggs is approximately 55 to 75 days, with an average of about 64 days (NMFS & USFWS 1992). Once hatchlings emerge, they immediately crawl to the sea and swim directly offshore (Ernst et al. 1994). They will actively and continuously swim offshore for at least six days (Musick and Limpus 1997). Very little is known about the fate of hatchlings after they leave the nesting beach (NMFS & USFWS 1992). There are few records of juvenile leatherbacks (less than 110 cm), perhaps a result of their pelagic habitat (NMFS & USFWS 1995). This stage of leatherback life history, known as the "lost years," remains a mystery.

Although leatherbacks are pelagic, they will enter temperate and boreal coastal waters to feed (Musick and Limpus 1997). Based on stranding data, these animals are usually large juveniles or adults, with lengths ranging from 110 to 120 cm (NMFS & USFWS 1992). Aerial surveys of the United States Outer Continental Shelf between North Carolina and Nova Scotia found that leatherbacks were present throughout the study area from April to November and that sightings peaked progressively earlier in the year moving south along the coast (NMFS & USFWS 1992, 1995). During the summer leatherbacks were seen more often at higher latitudes than other species of sea turtles. Records of sightings, aerial surveys, and strandings indicate that leatherbacks are present in the Chesapeake Bay during the summer and early fall, from approximately June until October (Hardy 1969; NMFS & USFWS 1992).

Most species of sea turtles are benthic feeders (Eckert et al. 1989). The leatherback is unique as a surface and midwater column forager that prefers a variety of soft-bodied marine organisms, particularly sea nettles and jellyfish (Schyphomedusidae) (Mortimer 1995; NRC 1990). Stomach contents have revealed that they also eat bivalves, crabs, tunicates, and small fish (Ernst et al. 1994). Data from the western Atlantic indicate that adult leatherbacks migrate long distances between tropical and temperate waters, presumably to optimize foraging and nesting opportunities (NMFS & USFWS 1995). The longest documented migration of a leatherback was an adult female that nested in Surinam and then traveled 5,900 km to Ghana, West Africa (Pritchard 1973). These animals will follow similar migration routes year after year and travel in deep water off the coast (NMFS & USFWS 1995). The age at which leatherbacks reach sexual maturity is unknown, but some data suggests that it may be at an earlier age than other sea turtles (NMFS & USFWS 1992).

Status

The leatherback is endangered throughout its range, but is inadequately protected in many regions of the world (NMFS & USFWS 1995). Based on the results of a mathematical model, Spotila et al. (2000) predicted that leatherbacks in the Pacific are on the verge of extinction as the result of unsustainable adult mortality due to human fishing activity. The leatherback was first listed as endangered by the United States Department of the Interior in June 1970 (35 FR 8495), and its status has remained unchanged. This status was adopted by the Maryland DNR through the Maryland Endangered Species Act of 1971 and the leatherback was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04; Taylor 1984).

Kemp's Ridley Sea Turtle, Lepidochelys kempii

Species Description

An adult Kemp's ridley, *Lepidochelys kempii*, has a heart-shaped or nearly round carapace that is almost as wide as it is long (USFWS & NMFS 1992). The carapace is charcoal gray in juveniles and olivegray in adults, and the plastron appears cream-white or yellowish throughout development (NMFS & USFWS 1995; NRC 1990). The head and limbs are gray (Carr 1952). There are two pairs of prefrontal scales between the eyes and five vertebral scutes, five pairs of lateral scutes (rarely more), and 12 pairs of marginal scutes on the carapace (USFWS & NMFS 1992). Ventrally there are four pairs of inframarginal scutes on the bridge between the carapace and the plastron, each of which is perforated with a pore (Marquez 1990).

Together with its congener, the olive ridley, the Kemp's ridley is the smallest of all sea turtles (Ernst et al. 1994). A typical adult ridley has a straight carapace length of 55 to 80 cm and weighs about 40 to 50 kg (Marquez 1990; NMFS & USFWS 1995). In Maryland waters stranded Kemp's ridley carapace lengths range from 30 to 63 cm (scl, notch to tip). Hatchlings, which are dark gray to black in color, usually weigh about 15 to 20 g and have a straight carapace length of 42 to 48 mm (Hirth 1980; NRC 1990; USFWS & NMFS 1992).

Distribution

The Kemp's ridley is one of two species of sea turtles with a relatively restricted range (the other is the flatback turtle, *Natator depressus*). Adults are usually confined to the Gulf of Mexico, but juveniles are found in the western Atlantic, particularly along the southeastern coast of the United States (USFWS & NMFS 1992). Smaller concentrations of turtles also occur along the Atlantic coast as far north as Massachusetts, and occasionally in the eastern Atlantic, Azores, and Morocco (Carr 1952; Marquez 1990). Kemp's ridley strandings have occurred as far north as Kent Island, Queen Anne's county in the Chesapeake Bay and along the Maryland coast (see Appendix I).

Life History

Kemp's ridleys have a very restricted nesting range (NMFS & USFWS 1995). The only major nesting beach is located near Rancho Nuevo, Mexico, where 95% of the nests are laid along 30 km of beach (NRC 1990). Sporadic nesting has occurred at other locations in Mexico, Texas, Veracruz, and along Florida's Gulf and Atlantic coasts (NMFS & USFWS 1995; NRC 1990). Females typically nest between April and July (Hirth 1980). The incubation period for Kemp's ridley eggs is approximately 45-58 days depending on incubation temperature (USFWS & NMFS 1992). As with loggerhead and leatherback sea turtles, the hatchlings, upon entering the ocean, are rarely seen until they become juveniles (Musick and Limpus 1997). They may become trapped in currents, such as the north-flowing Loop Current, and carried elsewhere in the Gulf of Mexico or northward along the Atlantic coast in the Gulf Stream (Carr 1980). Occasionally, some hatchlings are carried to the eastern Atlantic by the Gulf Stream and North Atlantic gyre and presumably lost to the population (Musick and Limpus 1997; NRC 1990). It is thought that Kemp's ridleys spend a few years (about two) as surface pelagic drifters, inhabiting floating mats of *Sargassum* and vegetation (Zug et al. 1997; NMFS & USFWS 1995).

Juvenile Kemp's ridleys (20 to 25 cm scl) enter inshore waters from Long Island Sound to the Gulf of Mexico (USFWS & NMFS 1992). They inhabit bays, sounds, and river mouths along the Atlantic coast from spring (May and June) until fall (September to November), when they depart inshore waters and move south, following a similar route as the loggerhead sea turtle. Kemp's ridleys spend the winter off the Carolinas and Florida coasts (Musick and Limpus 1997). The Chesapeake Bay is thought to be an important summer feeding ground and developmental habitat for juvenile Kemp's ridleys (Hardy 1962; Lutcavage and Musick 1985). The summer population has been estimated to be at minimum 200 to 1100 individuals (Keinath et al. 1994). They seem to prefer shallow habitats and seagrass beds where benthic invertebrates, particularly the blue crab (*Callinectes sapidus*), are plentiful (Lutcavage and Musick 1985; Musick and Limpus 1997). Typically, juveniles and adults in the Gulf of Mexico inhabit inshore waters to a depth of approximately 50 m and move to deeper waters within the Gulf as water temperatures cool. Adults in the Gulf of Mexico are benthic feeders that eat a variety of marine organisms, including crabs, mollusks, fish, shrimp, and vegetation (NMFS & USFWS 1995; NRC 1990;). Post-nesting females travel from Mexico along narrow corridors in coastal waters to feeding areas throughout the Gulf of Mexico.

Status

The Kemp's ridley is the most endangered sea turtle in the world and is in danger of extinction as the result of intensive harvest of eggs and mortality of juveniles and adults in trawl fisheries (USFWS & NMFS 1992). Complete recovery of the species is not likely (NMFS & USFWS 1995). The species was listed as endangered throughout its range by the United States Department of the Interior in December

1970, and its status has remained unchanged (35 FR 18320). This status was adopted by the Maryland DNR through the Maryland Endangered Species Act of 1971 and the Kemp's ridley was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04).

Marine Mammals

There are 78 species of currently recognized cetaceans (whales, dolphins, and porpoises) that are divided into two groups, the baleen whales (suborder Mysticeti) and the toothed whales (suborder Odontoceti). In addition, there are 34 species of pinnipeds (seals, sea lions, and walruses) that are assigned to three families of the mammalian order Carnivora: the Otariidae (eared seals), Phocidae (true seals), and Odobenidae (walrus). In Maryland waters, 22 species of cetaceans, four species of pinnipeds, and the West Indian manatee (order Sirenia) have been recorded. The following species have been sighted or have stranded in Maryland: humpback whale, fin whale, Minke whale, sei whale, blue whale, northern right whale, bottlenose dolphin, harbor porpoise, common dolphin, Atlantic spotted dolphin, striped dolphin, Atlantic white-sided dolphin, Risso's dolphin, Cuvier's beaked whale, True's beaked whale, pygmy sperm whale, dwarf sperm whale, sperm whale, killer whale, long-finned pilot whale, short-finned pilot whale, melon-headed whale, harbor seal, harp seal, hooded seal, gray seal, and West Indian manatee. Since the inception of the Maryland Marine Mammal and Sea Turtle Stranding Network in 1990, 115 dead (representing 17 species) and 22 live (representing 6 species) marine mammals have stranded in Maryland's Chesapeake Bay and along the coast (see Appendix I). The Maryland Stranding Network has also assisted neighboring states with more than 40 marine mammal strandings. Following are descriptions of eight of the more commonly stranded marine mammals in Maryland waters.

Humpback Whale, Megaptera novaengliae

Species Description

Humpback whales are black or gray dorsally and on the flanks, and white ventrally (Leatherwood and Reeves 1983). The dorsal surface of the flippers varies in color from all black to all white. The ventral surface of the flukes can be completely or partially white, forming unique patterns that allow researchers to identify individual whales (NMFS 1991a; Evans 1987). The flippers are very long, about one-third to one-fourth of the total body length and have knobs or bumps along the leading edge (Jefferson et al. 1993; Perry et al. 1999). The head is broad and rounded with many knobby protuberances (each containing a hair follicle) along the upper and lower edges of the jaw and on top of the head (Minasian et al.1984; Winn and Reichley 1985). There are 270 to 440 grayish-black baleen plates on each side of the upper jaw, which can reach 60 to 70 cm in length (Jefferson et al.1993; NMFS 1991a).

There are several body characteristics that distinguish the humpback whale from other whales in the Balaenopterid family. These include a more robust body, very long flippers, fewer throat grooves (14-35) and variable dorsal fin position and size, which can range from a small, slightly rounded triangle to a sharply falcate fin (Jefferson et al.1993; NMFS 1991a; Winn and Reichley 1985). Humpbacks are the most vocal of the baleen whales (Payne and McVay 1971). During the breeding season males utilize complex, repetitive songs that can last as long as thirty minutes (Perry et al. 1999).

Adult humpback whales are typically 11 to 16 m in length, with females slightly larger than males, and can weigh 34 to 40 tons (Perry et al. 1999; Wynne and Schwartz 1999). Newborn calves are usually 4.5 to 5 m in length and weigh approximately 2 tons (Jefferson et al. 1993; Wynne and Schwartz 1999).

Distribution

Humpbacks are distributed worldwide in all ocean basins, though they are less commonly seen in Arctic waters (NMFS 1991a). They are a migratory species that spend the summer months feeding in highly productive polar waters and the winter months breeding in temperate or tropical coastal waters that also serve as calving grounds (Leatherwood and Reeves 1983; Perry et al. 1999). In the western North

Atlantic whales migrate to feedings grounds in the Gulf of Maine, the Gulf of St. Lawrence, and waters off the coast of southern Labrador, Newfoundland, southwest Greenland, Iceland, and Norway during the summer months (Katona and Beard 1991; Weinrich et al. 1997; Wiley et al. 1995). In the fall whales from all known feeding stocks migrate to Caribbean waters for breeding and calving (Leatherwood and Reeves 1983; Perry et al. 1999). During the winter months the largest concentrations of whales (85%) can be found on Silver and Navidad Banks off the northern coast of the Dominican Republic. The remainder of the whales can be found along the northwest coast of Puerto Rico, the Virgin Islands, the eastern part of Samana Bay (Dominican Republic), and along the eastern Antilles (Katona and Beard 1991; Mattila et al. 1989; Perry et al. 1999). Between these migratory endpoints, little is known of the distribution of the species. In recent years, there has been an increase in the frequency of sightings and strandings of humpback whales off the mid-Atlantic coast of the United States (Swingle et al. 1993; Wiley et al. 1995). Juvenile humpback whales were observed in nearshore waters off the Virginia coast in January of 1991 and 1992 (Swingle et al. 1993) and several humpback whales were seen feeding under the Chesapeake Bay Bridge (in Maryland) in 1992. These observations suggest that segregation by age and reproductive class occurs for migrating humpback whales. It appears as though some juveniles do not migrate to breeding grounds in the winter months, but instead, migrate to the mid-Atlantic nearshore waters to feed (Swingle et al. 1993).

Life History

Humpbacks usually occur individually or in groups of two or three, but during the breeding and feeding seasons they may aggregate in groups of up to twenty or more (Jefferson et al.1993; Leatherwood and Reeves 1983). Many whales apparently migrate to specific feeding and breeding areas every year (Mattila et al.1989; NMFS 1991a). On the breeding grounds sexually mature males use complex songs as part of a breeding display to compete for estrus females. Males may also engage in fights to determine which male will mate with a female (Minasian et al. 1984). Females reach sexual maturity at about 12 m and an average age of 5 years and males at about 11 m and an average age of 6 or 7 years (Clapham 1992; Winn and Reichley 1985). Sexually mature females give birth to a single calf every 2 to 3 years after a gestation period of 11 to 12 months (Katona and Beard 1991; Winn and Reichley 1985). Annual calving has been occasionally observed, but it is unusual (NMFS 1991a). The calf will nurse for 10 to 11 months and is about 8 to 9 m long when weaning is completed (Leatherwood and Reeves 1983). Calves are born on the wintering grounds (between January and March) in tropical waters and a male escort is often seen accompanying a mother with a calf (NMFS 1991a; Perry et al. 1999).

Humpback whales feed on krill, copepods, sand lance, herring, capelin, mackerel, Arctic cod, pollack, anchovy, and other small schooling fish (Perry et al. 1999; Weinrich et al.1997; Winn and Reichley 1985). They utilize a number of unique feeding methods including: 1) the use of columns or nets of expelled bubbles to concentrate prey; 2) herding and possibly immobilizing prey with the flukes and flippers; 3) using the surface of the water as a barrier to keep prey from escaping (lunge feeding); 4) feeding in formation (echelon feeding); 5) use of acoustic cues to coordinate feeding attacks; and 6) cooperative feeding (NMFS 1991a; Perry et al. 1999; Winn and Reichley 1985;).

Status

Commercial whalers heavily exploited the humpback whale throughout its range until the middle of the twentieth century. This species was listed as endangered throughout its range in 1970 (35 FR 8495) and its status has remained unchanged. Humpback whales are also protected under the MMPA of 1972 (Perry et al. 1992). This status was adopted by the Maryland DNR through the Endangered Species Act of 1971 and the humpback whale was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04; Taylor 1984).

Fin Whale, Balaenoptera physalus

Species Description

The body color of the fin whale is dark brownish gray to black dorsally and on the flanks, and white ventrally, including the undersides of the flukes and flippers (Gambell 1985; Jefferson et al. 1993). The coloration on the head is asymmetric; the lower right jaw and the right front baleen are white or yellowish white, while the lower left jaw is dark (Leatherwood and Reeves 1983; Perry et al. 1999). Along the back of most animals, just behind the head, there is a light gray V-shaped chevron, which may be visible when the whale surfaces (Jefferson et al. 1993). Fin whales are long and streamlined, with a pointed, V-shaped rostrum and a flattened head that has up to 100 tactile hairs on the tips of the upper and lower jaws (Leatherwood and Reeves 1983; Minasian et al.1984). There is a distinct ridge on the back running from the dorsal fin to the broad triangular flukes (Wynne and Schwartz 1999). The falcate dorsal fin, which can be up to 60 cm tall, is located about two-thirds of the body length back on the dorsal ridge (Geraci and Lounsbury 1993; Leatherwood and Reeves 1983). There are 260 to 480 baleen plates on each side of the upper jaw, which can reach up to 72 cm in length, and 50 to 100 ventral throat grooves that extend to the navel (Jefferson et al. 1993; Wynne and Schwartz 1999).

Fin whales are the second largest baleen whale species by length (Gambell 1985). Adult fin whales can reach a maximum length of 24 m and 27 m in the northern and southern hemispheres, respectively, and weigh as much as 60 to 70 tons (Geraci and Lounsbury 1993; Jefferson et al. 1993). As with other baleen whales, females grow to a slightly larger size than males. Newborns are usually 6 to 6.5 m in length and weigh approximately 2 tons (Mizroch et al. 1984; Perry et al. 1999).

Distribution

Fin whales inhabit oceanic waters around the globe, but are less common in tropical waters than temperate and polar waters (Jefferson et al.1993; Leatherwood and Reeves 1983;). They are most abundant in offshore waters where prey is plentiful (Perry et al. 1999). Like many other baleen whales, fin whales move seasonally between high latitude feeding grounds in the summer and temperate and tropical breeding grounds in the winter (Mizroch et al.1984). While the concentration of whales within a particular area may change seasonally, the movements of individual whales vary depending on prey availability, physical condition, and environmental factors (Hain et al.1992; Minasian et al.1994). In the western North Atlantic, fin whales winter from the edge of the arctic ice packs (off the coasts of Newfoundland and Labrador) south to the West Indies and Gulf of Mexico and summer from Cape Cod to the Arctic Circle (Leatherwood and Reeves 1983; Mizroch et al.1984; Perry et al. 1999).

Life History

While fin whales are sometimes found individually or in pairs, they tend to aggregate in groups of three to ten whales, and sometimes as many as a hundred or more individuals will congregate on the feeding grounds (Gambell 1985; Wynne and Schwartz 1999). Evidence from photo-identification studies suggests that some whales may return to the same feeding grounds annually (Edds and MacFarlane 1987; Seipt et al. 1989). Most mating and births occur in the winter (November to March) while the whales are in temperate or tropical waters (Jefferson et al.1993; Perry et al. 1999). Sexual maturity is reached at 5 to 15 years of age for both sexes, with average lengths of about 17.7 m for males and 18.3 m for females (Leatherwood and Reeves 1983; Perry et al. 1999). Sexually mature females give birth to a single calf every 2 to 3 years after a gestation period of 11 to 12 months (Mizroch et al.1984; Wynne and Schwartz 1999). The calf will nurse for 6 or 7 months and is about 11 to 12 m when weaning is completed (Gambell 1985; Geraci and Lounsbury 1993; Mizroch et al.1984). Calves usually travel with small adult groups of 2 to 4 animals, but have been seen with groups as large as 20 animals (CETAP 1982).

Depending on prey abundance, fin whales feed on small invertebrates, particularly krill, squid, and copepods, and schooling fish such as capelin, anchovies, herring, and sand lance (CETAP 1982; Leatherwood and Reeves 1983; Perry et al. 1999; Wynne and Schwartz 1999). The availability of prey is thought to affect the distribution and movement of fin whales along the eastern coast of the United States (Hain et

al.1992; Payne et al.1990). Fin whales utilize a number of foraging techniques, but often lunge feed or engulf large swarms of fish or plankton while swimming on their right side (Jefferson et al.1993; Wynne and Schwartz 1999).

Status

As stocks of blue whales became depleted, whalers turned their attention to fin whales, resulting in a severe reduction in populations worldwide (Jefferson et al.1993; Leatherwood and Reeves 1983). In 1987 the International Whaling Commission gave the fin whale full protection from commercial whaling in the North Atlantic. The fin whale was listed as endangered throughout its range in 1970 under the Endangered Species Conservation Act of 1969 and its status has remained unchanged (35 FR 8495). This species is also protected under the MMPA of 1972. The Federal status was adopted by the Maryland DNR through the Maryland Endangered Species Act of 1971 and the fin whale was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04; Taylor 1984).

Sperm Whale, Physeter catodon

Species Description

Sperm whales are predominately dark brownish gray, with some paler areas on the front of the head and the belly and white around the mouth (Evans 1987). The body, with the exception of the head, is corrugated, giving the animal a wrinkled appearance (Leatherwood and Reeves 1983). The head is huge (occupying at least one third of the total body length) and square, and projects well beyond the narrow, underslung, lower jaw (Jefferson et al. 1993; Perry et al. 1999). There are 18 to 25 conical teeth on each side of the lower jaw that fit into sockets in the upper jaw. Teeth are generally absent from the upper jaw (Geraci and Lounsbury 1993; Minasian et al. 1984). The flippers are small, wide, and shaped like spatulas (Jefferson et al. 1993). A distinct triangular or rounded dorsal hump lies about two-thirds of the way back along the body, followed by a series of bumps, or crenulations, along the dorsal ridge of the tailstock (Jefferson et al. 1993; Leatherwood and Reeves 1983). The flukes, which are broad and triangular, have a straight trailing edge and are deeply notched (Wynne and Schwartz 1999).

The sperm whale is the largest and the most sexually dimorphic member of the toothed whales (Perry et al. 1999). Adult males are typically 15 to 18.5 m in length and weigh 45 to 70 tons and adult females are 11 to 12.5 m in length and weigh 15 to 20 tons (Evans 1987; Geraci and Lounsbury 1993). Newborns are usually 3.5 to 4.5 m in length and weigh approximately one ton (Leatherwood and Reeves 1983; Wynne and Schwartz 1999).

Distribution

Sperm whales are widely distributed in all oceans throughout the world between 70° N and 70° S. Females and juveniles tend to remain between 40° N and 40° S, and only the largest males migrate to the most poleward portions of the range (Evans 1987; Jefferson et al.1993). Distribution varies by gender and age, and is related to prey availability and certain oceanic conditions (Minasian et al.1984; Perry et al. 1999). However, the majority of sperm whales, regardless of sex or age, move poleward in the spring and summer and return to the temperate and tropical portions of their range in the fall (Leatherwood and Reeves 1983). In the summer, all sperm whales can be found at the highest latitudes of their range. In the winter, females and juveniles migrate closer to equatorial waters, and sexually mature males join these groups throughout the winter (Perry et al. 1999). In the north Atlantic, sperm whales range as far north as Davis Strait and Newfoundland Grand Banks in the summer and as far south as the Azores and Madeira in the winter. Portions of the Grand Banks, waters off the Carolinas and Bahamas, the west coast of the British Isles, and the tropical mid-Atlantic are believed to be the most important historical grounds for sperm whales (Evans 1987; Leatherwood and Reeves 1983; Minasian et al.1984). In United States waters, sperm whales are present year round in the Gulf of Mexico and from North Carolina to Georges Bank, Nova Scotia (Wynne and Schwartz 1999). Sperm whales are generally pelagic and inhabit deep waters

near the continental shelf, but they move into shallower waters (less than 200 m deep) in the spring and fall (Jefferson et al. 1993; Wynne and Schwartz 1999).

Life History

Sperm whales are found in highly social, sexually segregated groups ranging from ten to fifty individuals (Geraci and Lounsbury 1993). These distinct groups may consist of sexually inactive males (called "bachelor" schools), adult females and their offspring (called "nursery" or "breeding" groups), or juveniles of both sexes. Older males are usually found singly or in small groups except for brief periods of time during the breeding season when they join nursery groups to mate (Jefferson et al.1993; Leatherwood and Reeves 1983). Most mating and births occur in the tropical and subtropical waters. Mating occurs in the spring and early summer, from April to June, and most births take place in the summer and fall, from July to November (Evans 1987; Perry et al. 1999). Females reach sexual maturity at 8 to 11 years, when they are about 8 to 9 m in length, and males at 20 years and 10 to 12 m in length. Sexually mature females give birth to a single calf every 3 to 6 years after a gestation period of 14 to 16 months. The calf will nurse for 12 to 24 months and is about 6.7 m in length when weaning is completed (Geraci and Lounsbury 1993; Perry et al. 1999).

Sperm whales are capable of reaching depths of more than 3,200 meters and staying submerged for two hours, making them the deepest and longest diving cetacean (Jefferson et al.1993; Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Sperm whales usually hunt singly or in small groups. The diet is almost exclusively squid (up to one ton per day, Wynne and Schwartz 1999), although they may occasionally eat octopus and a variety of fish, including salmon, redfish, rockfish, and skates (Evans 1987; Leatherwood and Reeves 1983). A variety of unusual objects, such as rocks, sand, deep-sea sponges, crab meat, clams and a boot, have been found in the stomachs of sperm whales. This suggests that sperm whales sometimes feed along the sea bottom (Leatherwood and Reeves 1983).

Status

Commercial whaling of sperm whales began in 1712 and has continued sporadically to the present day (Leatherwood and Reeves 1983). More than one million whales have been taken by the whaling industry over the last 200 years, yet this species remains the most abundant of the large whale species (Jefferson et al.1993). It was listed as endangered throughout its range in 1970 under the Endangered Species Conservation Act of 1969 and its status remains unchanged (35 FR 8495). This species is also protected under the MMPA of 1972. The Federal status was adopted by the Maryland DNR through the Maryland Endangered Species Act of 1971 and the sperm whale was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04; Taylor 1984).

Minke Whale, Balaenoptera acutorostrata

Species Description

Minke whales are dark gray to black dorsally and ventrally at the flukes and white from the throat to the anus and on the underside of the flippers (Jefferson et al. 1993). There may be a pale chevron behind the head and streaks of light gray on each side of the body (Wynne and Schwartz 1999). Whales in the Northern Hemisphere (and less frequently in the Southern Hemisphere) usually have a distinctive white band across each flipper that varies among individuals in extent and orientation (Evans 1987; Leatherwood and Reeves 1983). Minke whales can be distinguished from other whale species by a extremely narrow, pointed rostrum with a single prominent ridge that runs from the tip of the rostrum to the blowhole (Minasian et al. 1984; Steward and Leatherwood 1985). The body is slender and streamlined, the flippers are small (about one-eighth the total body length), thin and pointed at the tips and the flukes are broad (about one-fourth the total body length) and notched (Evans 1987; Stewart and Leatherwood 1985; Wynne and Schwartz 1999). Minke whales have a relatively tall, falcate dorsal fin situated two-thirds of the way back on the body (Geraci and Lounsbury 1993; Jefferson et al. 1993). There are 230 to 360

baleen plates on each side of the upper jaw, which can reach 30 cm in length, and 50 to 70 throat grooves that extend to the navel (Geraci and Lounsbury 1993; Leatherwood and Reeves 1983; Wynne and Schwartz 1999).

This species is the smallest of the rorquals (includes fin and humpback whales) and the second smallest of the baleen whales (Stewart and Leatherwood 1985). Adults are typically 9 to 10 m in length in the Northern Hemisphere (slightly larger in the Southern Hemisphere) and can weigh as much as 10 to 14 tons (Evans 1987; Jefferson et al. 1993; Wynne and Schwartz 1999). As with other baleen whales, females are slightly larger than males (Wynne and Schwartz 1999). Newborns are usually 2.4 to 2.8 m in length and weigh approximately one-half a ton (Geraci and Lounsbury 1993; Minasian et al. 1984).

Distribution

The minke whale is widely distributed in tropical, temperate, and polar waters in all ocean basins (Jefferson et al. 1993; Leatherwood and Reeves 1983). This species frequents shallow coastal areas, bays, and estuaries as well as pelagic waters (Geraci and Lounsbury 1993; Wynne and Schwartz 1999). Although the species appears to be widely distributed throughout the year, they tend to migrate from polar feeding grounds in the summer to warm temperate and tropical breeding grounds in the winter (Evans 1987). In the western North Atlantic, minke whales migrate to the Gulf of St. Lawrence, the Newfoundland and Greenland coasts, Davis Strait, and Baffin Bay in the summer and move southward to the Florida Keys, Gulf of Mexico, and West Indies in the winter (Jonsgard 1966; Leatherwood and Reeves 1983; Stewart and Leatherwood 1985; Sergeant 1963). Similar to sperm whales, it appears as though sexual and age segregation occurs during the summer. The males tend to move farther north in pelagic waters while females remain in more southern and coastal waters and juveniles occur still farther south (Schwartz 1962; Sergeant 1963; Stewart and Leatherwood 1985).

Life History

Minke whales occur singly or in groups of two or three (Geraci and Lounsbury 1993), though they may aggregate to feed in polar waters during the summer (Jefferson et al. 1993). Most mating and births occur in the winter (October to March) while the whales are in temperate or tropical waters (Jefferson et al. 1993; Sergeant 1963; Stewart and Leatherwood 1985). Minke whales become sexually mature at 6 to 8 years of age, at which time the females are 7.3 to 7.9 m and the males are 6.7 to 7.9 m in length (Leatherwood and Reeves 1983; Stewart and Leatherwood 1985). Sexually mature females give birth to a single calf every one to two years after a gestation period of 10 to 11 months (Wynne and Schwartz 1999). The calf will nurse for 3 to 6 months and is about 5 m in length when weaning is completed (Geraci and Lounsbury 1993; Stewart and Leatherwood 1985).

Minke whales feed on a variety of schooling fish (capelin, herring, sand lance, cod, mackerel, salmon, pollack), squid, krill, and copepods (Sergeant 1963; Stewart and Leatherwood 1985; Wynne and Schwartz 1999). Their feeding behavior is similar to that of other baleen whales. They use an engulfing method to capture large numbers of fish or krill (Stewart and Leatherwood 1985).

Status

Minke whales have been hunted for meat and oil since the early twentieth century, and often comprised a large percentage of the permitted catch. In the late 1970s whaling was regulated and limits were placed on the number of whales that could be taken (Stewart and Leatherwood 1985). Commercial whaling of minke whales continues in some parts of the world, particularly in the Antarctic, Norway, and Japan (Jefferson et al. 1993; Stewart and Leatherwood 1985). Despite the great whaling efforts over the past century, minke whales are not listed as threatened or endangered in the United States or worldwide. In fact, minke whales are considered quite common and are the most abundant of the baleen whales (Jefferson et al. 1993; Wynne and Schwartz 1999). It is estimated that as many as 13,000 whales may inhabit United States Atlantic waters (Wynne and Schwartz 1999).

Bottlenose dolphin, Tursiops truncatus

Species Description

The coloration of the bottlenose dolphin is highly variable among individuals. Generally, they are dark dorsally and become lighter ventrally (Geraci and Lounsbury 1993). Color varies from light gray to nearly black dorsally, lighter gray on the flanks (variable in extent), and white or pink on the belly (Evans 1987; Jefferson et al. 1993). Some animals have spots on the belly and lower sides. There is a dark stripe from the eye to the flipper and a faint dorsal cape on the back, running from the top of the melon to behind the dorsal fin (Jefferson et al. 1993; Leatherwood and Reeves 1983). The bottlenose is a relatively large dolphin, with a robust head and body and a short, thick, well-defined beak that is set off from the forehead by a sharp crease (Geraci and Lounsbury 1993; Jefferson et al. 1993; Wynne and Schwartz 1999). The flippers are long and pointed at the tip and the flukes are deeply notched. The dorsal fin, which is tall, slender, and falcate, is located near the middle of the back (Evans 1987; Leatherwood and Reeves 1983). Bottlenose dolphins have 18 to 26 sharp, conical teeth in each side of the upper and lower jaws, which become worn down and often break as an animal ages (Jefferson et al. 1993; Wynne and Schwartz 1999).

The size of adults varies considerably between different populations, although males are typically larger than females. Adults range from 2 to 4 m in length and can weigh as much as 140 to 650 kg (Geraci and Lounsbury 1993; Wynne and Schwartz 1999). Newborns are usually 1 to 1.3 m in length and weigh approximately 12 to 25 kg (Geraci and Lounsbury 1993; Jefferson et al. 1993).

There appear to be two ecotypes, separated by morphology and ecology, of bottlenose dolphins in temperate and tropical waters: a coastal form and an offshore form. Generally, the coastal bottlenose is shorter and slimmer than the offshore type, which tends to be more robust and darker in color (almost black in some cases). Other differences between the two ecotypes include morphometrics, skull measurements, diet, parasites, and diving capabilities based on hematological differences (Hersh and Duffield 1990; Mead and Potter 1990). The systematics of *Tursiops* is poorly defined and some have suggested the need for a revision of the genus (Hersh and Duffield 1990; Leatherwood and Reeves 1983).

Distribution

The bottlenose dolphin is widely distributed in temperate and tropical waters around the world, avoiding only very high latitudes (Leatherwood and Reeves 1983). The coastal ecotype is usually found in coastal and inshore waters, including harbors, bays, lagoons, estuaries, and river mouths, while the offshore ecotype is found in more pelagic waters (Kenney 1990; Leatherwood and Reeves 1983). In the western Atlantic, bottlenose dolphins range from Nova Scotia to Patagonia, Argentina (Evans 1987; Kenney 1990). They are distributed throughout the Gulf of Mexico and along the Atlantic coast of the United States (Wang et al. 1994). The coastal stock occurs from New York to the Florida Keys, usually in waters less than 25 m deep, while the offshore stock is found along the continental shelf and in pelagic waters from Cape Hatteras, North Carolina to Georges Bank. South of Cape Hatteras the coastal/offshore separation becomes less distinct and data on distribution of the two stocks are sparse (Young et al. 1993).

The majority of the coastal concentrations of migratory dolphins occur from North Carolina to New Jersey. In the spring and summer, the coastal population is found from New York to Florida. As fall arrives, the dolphins begin to migrate south, and by winter, their distribution extends from Cape Hatteras, North Carolina to the Florida Keys (Wang et al. 1994). Within coastal areas there are both resident and migratory dolphins. Residents can be found year round south of Cape Hatteras and in the Gulf of Mexico (Wynne and Schwartz 1999; Young et al.1993). During the spring, the coastal migratory population shifts northward along the coast. The offshore population is thought to occur primarily from Georges Bank to Cape Hatteras in the winter and from Nova Scotia to the Florida Keys in the spring through fall, but the extent of their distribution and seasonal migration is unclear (Wang et al.1994; Wynne and Schwartz

1999). Kenney (1990) reported that the abundance of offshore dolphins was much lower along the northeastern United States (Cape Hatteras, North Carolina north to Georges Bank) in the winter, suggesting that this stock moves south as the temperatures decline (Young et al. 1993).

Life History

Coastal bottlenose dolphins typically occur in groups of less than ten individuals, while the offshore animals are found in groups of less than twenty-five individuals (Leatherwood and Reeves 1983). However, herds of several hundred animals have been seen both offshore and along the United States' Atlantic coast (Jefferson et al. 1994; Wang et al. 1994). The calving season is prolonged, occurring primarily in the spring and summer, with a peak in March (Mead and Potter 1990; Minasian et al. 1984). Females reach sexual maturity at 5 to 12 years and a length of approximately 222 to 235 cm, and males at 10 to 13 years and a length of approximately 245 to 260 cm (Leatherwood and Reeves 1983; Mead and Potter 1990). Sexually mature females give birth to a single calf every two to three years, after a gestation period of about 12 months (Leatherwood and Reeves 1983; Schroeder 1990). The calf will nurse for a year or longer (Wynne and Schwartz 1999).

Dolphins segregate into groups based on sex and age, although individuals may be seen with a variety of different associates. A mother-calf pair forms a very strong bond, and may remain together for three to six years (Wells 1991). After leaving their mothers young dolphins join groups of subadults. Adult males may form strong long-term associations with other males (usually one or two) for the purposes of mating, feeding, and predator detection (Wells 1991). Bottlenose dolphins are opportunistic feeders, taking whatever suitable prey is abundant at the time. Generally, offshore bottlenose dolphins feed on pelagic squid and small fish, while coastal dolphins feed primarily on fish and invertebrates. Studies indicate the preferred diet of the coastal dolphins in the western North Atlantic are sea trout, croaker, and spot. Mullet, gizzard shad, and coastal squid may also be important in their diet (Mead and Potter 1990; Wang et al.1994). Dolphins use a variety of feeding methods, including cooperative foraging, feeding on bycatch discarded by trawlers, and shallow water feeding, in which the dolphins chase individual prey onto the mudbanks (Jefferson et al. 1993; Leatherwood and Reeves 1983; Shane 1990).

Status

The bottlenose dolphin is generally common, but some coastal stocks are depleted as the result of commercial fisheries. The best-known and documented example of the incidental take of dolphins is in the eastern Tropical Pacific tuna purse seine fishery, in which an estimated 350,000 to 650,000 dolphins died each year between 1959 and 1972 (Goslinger 1999; Hofman 1990). In 1987, an apparent disease epidemic caused by a combination of factors including brevetoxin (a toxin produced by the dinoflagellate responsible for Florida's red tide) and morbillivirus, resulted in the death of an estimated 50% or more of the coastal migratory stock of bottlenose dolphins between Florida and New Jersey (Geraci 1989; Lipscomb et al. 1994; Scott et al. 1988). As a result, in 1993 the NMFS listed the coastal migratory stock of bottlenose dolphins as depleted under the MMPA and required that a conservation plan be developed (Wang et al. 1994).

Harbor Porpoise, Phocoena phocoena

Species Description

The harbor porpoise is variable in color and has no distinctive markings. Generally, they are dark gray or black dorsally with lighter grayish brown flanks and a white belly (Leatherwood and Reeves 1983). The lighter area of gray extends farther up the flanks in front of the dorsal fin than behind it. The flippers and lips are dark and there is a thin, dark stripe between the gape of the mouth and the flipper (Jefferson et al. 1993; Wynne and Schwartz 1999). The harbor porpoise has a small, chunky body with a blunt head and no forehead or defined beak (Evans 1987; Leatherwood and Reeves 1983). The flippers are small, short, and not sharply pointed and the flukes are rounded at the tips and separated by a promi-

nent median notch. The dorsal fin, which is short, broad-based, and triangular in shape (not sharply pointed), is placed about midway along the back and sometimes has small bumps on the leading edge (Geraci and Lounsbury 1993; Jefferson et al. 1993). There are 19 to 28 small, spade-shaped teeth on each side of the upper and lower jaws (Evans 1987).

The harbor porpoise is the smallest cetacean in United States Atlantic waters. Adults are typically 1.4 to 1.8 m in length, with females slightly larger than males, and can weigh as much as 90 kg, although the average adult size is 45 to 60 kg (Geraci and Lounsbury 1993; Wynne and Schwartz 1999). Newborns are usually 0.7 to 0.9 m in length and weigh approximately 6.4 to 10 kg (Jefferson et al. 1993; Minasian et al. 1984).

Distribution

Harbor porpoises are distributed in cool temperate and subarctic waters of the Northern Hemisphere. They are typically found in coastal or nearshore waters, frequenting bays, rivers, estuaries, and tidal channels (Geraci and Lounsbury 1993; Leatherwood and Reeves 1983), although they may occasionally travel over deeper offshore waters in the winter (Jefferson et al. 1993). In the western North Atlantic, harbor porpoises are found from southern Baffin Island and central west Greenland south to North Carolina (Evans 1987; Leatherwood and Reeves 1983). In the summer (July to September) they are concentrated in the northern Gulf of Maine and southern Bay of Fundy in shallow waters less than 150 m deep (Palka et al. 1996; Young et al. 1993). During the fall (October to December) and spring (April to June) harbor porpoises are widely distributed from North Carolina to Maine, with concentrations in Cape Cod Bay, Massachusetts Bay, and Nantucket Shoals (NMFS 1998a; Young et al. 1993). It is thought that harbor porpoises spend the winter (December to March) in waters off the mid-Atlantic, from New Jersey to North Carolina, although records as far south as Florida have been reported (NMFS 1998a; Wynne and Schwartz 1999). In Maryland waters, harbor porpoise strandings occur primarily in the late winter and early spring, which may coincide with seasonal movements along the Atlantic coast.

Life History

Harbor porpoises usually occur singly, in pairs, or in small groups of up to ten individuals, although larger aggregations of 50 to several hundred animals may occur during feeding or seasonal migrations (Jefferson et al. 1993; Leatherwood and Reeves 1983). Mating is thought to occur in the summer (June to possibly October) and most calves are born from spring to mid-summer (Jefferson et al. 1993; Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Age at sexual maturity is estimated at 3 to 5 years. Sexually mature females give birth to a single calf every one or two years, after a gestation period of 10 to 11 months. The calf will nurse for 6 to 8 months and is about 1 m in length when weaning is completed (Geraci and Lounsbury 1993; Wynne and Schwartz 1999). Harbor porpoises eat a wide variety of fish and cephalopods (squid) but seem to prefer small, non-spiny schooling fish such as herring, mackerel, sardines, and pollack (Leatherwood and Reeves 1983).

Status

While world populations of harbor porpoises are not well studied, it appears as though numbers are declining. One of the major causes of mortality is incidental capture in commercial fisheries, particularly the gillnet fishery (Jefferson et al. 1993). In the United States the incidental take of harbor porpoises in commercial fisheries has increased over the last ten years (NMFS 1998a). As a result, the NMFS proposed listing the Gulf of Maine/Bay of Fundy population of harbor porpoises as threatened under the ESA in 1993 (58 FR 3108). In January 1999 the NMFS ruled not to list the population as threatened. Instead, the Gulf of Maine population was added to the candidate species list. In Canada, several initiatives were taken to reduce harbor porpoise mortality in fisheries, including the Cetacean Protection Regulations of 1982, which prohibited the catching or harassment of all species of cetaceans. These efforts have resulted in a reduction in bycatch to less than 50 harbor porpoises per year (NMFS 1998a).

Short-finned pilot whale, Globicephala macrorhynchus

Species Description

The short-finned pilot whale is dark brownish gray to black, with a light gray, anchor-shaped patch on the throat and a gray area of varying extent and intensity on the belly (Evans 1987). Some animals have a large, conspicuous gray saddle behind the dorsal fin and a light gray streak above each eye that extends high onto the back in the shape of an elongated teardrop (Jefferson et al. 1993). A light chevron may be present behind the blowhole (Leatherwood and Reeves 1983). The body is long and robust and the head is thick and bulbous, with a prominent melon and a short or non-existent beak (Geraci and Lounsbury 1993; Wynne and Schwartz 1999). The shape of the head varies with age and sex, becoming more square in adult males (Jefferson et al. 1993). The long, sickle-shaped flippers are less than one-sixth of the body length and the flukes have a concave trailing edge and are deeply notched. The dorsal fin is wide-based, low, and sickle to flag-shaped, and located slightly forward of midpoint (Evans 1987; Wynne and Schwartz 1999). In adult males the dorsal fin can be strongly hooked and have a thickened leading edge (Jefferson et al. 1993). There are usually 7 to 9 short, pointed teeth in the front of each of the upper and lower jaws (Leatherwood and Reeves 1983).

Adult males are typically 4.5 to 6 m in length and weigh 2 to 2.5 tons and adult females are 4.5 to 5.5 m in length and weigh 1 to 1.5 tons (Geraci and Lounsbury 1993; Jefferson et al. 1993; Evans 1987). Newborns are usually 1.4 to 2.0 m in length and weigh approximately 70 to 90 kg (Geraci and Lounsbury 1993).

Distribution

Short-finned pilot whales are distributed in warm temperate and tropical waters between 50° N and 40° S (Jefferson et al. 1993). They are found in both deep offshore waters and inshore waters, and movement between the two areas may coincide with seasonal prey availability (Leatherwood and Reeves 1983; Young et al. 1993). In the western North Atlantic, short-finned pilot whales generally range from Virginia to the Gulf of Mexico, although several stranding in Maryland and Delaware have been documented (Leatherwood and Reeves 1983; Wynne and Schwartz 1999). They are also common in the Caribbean and the islands of the West Indies. While it is thought that this species moves inshore to feed in the spring and fall (Geraci and Lounsbury 1993; Leatherwood and Reeves 1983), their seasonal distribution in the western North Atlantic is poorly understood (Young et al. 1993).

Life History

Short-finned pilot whales are gregarious, and groups of a few to several hundred individuals are common. They often associate with other species, especially bottlenose dolphins (Jefferson et al. 1993). It is thought that adults reach sexual maturity at 6 to 12 years of age, at a length of 3 to 3.3 m for females and 4.2 to 4.8 m for males (Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Sexually mature females give birth to a single calf every 3 to 3.5 years, after a gestation period of about 15 to 16 months. The calf will nurse for 20 months or more (Wynne and Schwartz 1999) and is about 2.4 m when weaning is completed (Geraci and Lounsbury 1993). Mating is thought to occur from April to June and calves are born throughout most of the year (Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Although detailed behavioral studies of short-finned pilot whales have only recently begun, it appears as though this species lives in relatively stable female-based groups. Post-reproductive females may continue to suckle young (both their own or related calves) for up to 15 additional years, suggesting a complex social structure based on cooperative behavior (Jefferson et al. 1993). Although they also take fish, short-finned pilot whales are thought to be primarily adapted to eating squid (Wynne and Schwartz 1999).

Status

Historically, short-finned pilot whales were killed for their oil and meat. Harvesting continues in some places, such as Japan, where several small coastal whaling stations and drive fisheries take a few

hundred animals annually. Harvesting of several hundred whales per year occurred in the Caribbean until the mid-1980's, but since then the numbers appear to have declined (Jefferson et al. 1993; Wynne and Schwartz 1999). They are known to be incidentally taken in several pelagic United States fisheries, including Atlantic mackerel and squid (Young et al. 1993). However, the irregular exploitation of short-finned pilot whales seems to have allowed the species to remain abundant and widely distributed, and their populations in the western North Atlantic do not appear to be in any imminent danger of depletion or extinction.

Harp seal, Phoca groenlandica

Species Description

The coloration and patterns of the harp seal coat vary considerably with sex and age (for review, see Lavigne and Kovacs 1988). Newborn pups have a pure white coat (which can be stained with amniotic fluids for the first few days, giving it a yellowish appearance) that persists for about twelve days. During their first molt (at about three weeks of age) the hair falls out in patches, giving them a "ragged-jacket" appearance. By four weeks of age a short, silvery, subadult coat with black spots develops ("beaters"). At one year of age, the beaters molt into an irregularly spotted coat that develops into the adult harp seal pattern with each annual molt (Lavigne and Kovacs 1988). The adult pattern is variable and complex. The body is silvery white or gray with a dark "harp" pattern, consisting of two dark bands of variable width, joined at the shoulders and bending posteriorly toward the abdomen and the area of the pelvis (Jefferson et al. 1993; Reeves et al. 1992). This pattern is often muted and less distinct in mature females (Geraci and Lounsbury 1993). The face is black, the fore flippers and belly are whitish and black marks may occur at the insertions of the hind flippers (Reeves et al. 1992). The body is robust, with a small, sleek head that appears somewhat flattened. The flippers are relatively small and the foreflippers, which are slightly pointed, have well-developed claws (Wynne and Schwartz 1999).

The average size of adults is 1.7 to 1.9 m and 120 to 135 kg, although their weight can vary considerably from year to year, to as much as 180 kg (Geraci and Lounsbury 1993; Jefferson et al. 1993). Males are slightly larger than females. Newborn pups are about 0.8 m in length and weigh 10 kg (Jefferson et al. 1993).

Distribution

Harp seals are found only in the Northern Hemisphere, in close association with ice packs in the Arctic and North Atlantic oceans (Jefferson et al. 1993). In the western North Atlantic, harp seals are found in the Gulf of St. Lawrence, waters off northeastern Newfoundland and southern Labrador, and areas adjacent to Hudson Bay and Baffin Island (Lavigne and Kovac 1988; Riedman 1990). Harp seals are migratory, and those in the western North Atlantic migrate between the high Arctic and Newfoundland or the Gulf of St. Lawrence (Reeves et al. 1992). They give birth at the southern edge of the ice pack (in the Gulf of St. Lawrence and off Newfoundland and Labrador) from late February until mid-March (Geraci and Lounsbury 1993). In April and May, adults assemble on ice north of the breeding grounds to undergo the annual molt (Lavigne and Kovac 1988). After molting, the seals migrate northward to summer feeding grounds. They move along the Labrador coast toward Greenland in late May and early June, feeding as they go. During the summer months harp seals are abundant along the west coast of Greenland, Jones Sound, Lancaster Sound, along the east coast of Baffin Island to Baffin Bay, and Hudson Strait, with some reaching Hudson Bay (Reeves et al. 1992; Lavigne and Kovac 1988). In late September, adult seals leave the Arctic and begin to migrate south. The majority of the seals travel to the northeast coast of Newfoundland and Labrador while others enter the Gulf of St. Lawrence. The adults spend most of December to February feeding in order to store energy to meet the demands of the nursing, mating and molting periods that are to follow (Lavigne and Kovac 1988).

Although most harp seals are found north of the Gulf of St. Lawrence, some animals range south into United States waters in January through May, when the population is at the southern limit of its migra-

tion. The number of harp seal strandings along the Atlantic coast of the United States has increased over the last few years, with strandings as far south as North Carolina. Several strandings occurred along the Maryland's Atlantic coast in the 1990s, suggesting that these animals may be extending their region for reasons that are yet unknown.

Life History

Harp seals are gregarious and congregate in large numbers on pupping and molting grounds (10,000s) and while feeding, migrating and resting in the summer (100s). Harp seals become sexually mature at 4 to 7 years of age (Wynne and Schwartz 1999). Despite reaching sexual maturity, males usually do not breed until they are 6 or 7 years old (Lavigne and Kovac 1988). Sexually mature females give birth to a single pup every year, after a gestation period of 11 to 12 months. The pup will nurse for an average of 12 days, and is about 1 m in length and 30 to 35 kg when weaning is completed (Wynne and Schwartz 1999; Reeves et al. 1992). Pups grow quickly on their mother's fat-rich milk (43 percent fat) and gain at least two kg per day during lactation (Lavigne and Kovac 1988; Reeves et al. 1992). Pups are born from late February through mid-March, and females may be able to delay giving birth for several days if conditions are not suitable for pupping (Reeves et al. 1992). After weaning their pups, females join adult males to mate (from mid to late March), in preparation for the next pupping season (Jefferson et al. 1993). Harp seals begin their annual molt in early April and continue through May, with adult males and juveniles starting a week or more earlier than adult females (Geraci and Lounsbury 1993; Lavigne and Kovac 1988).

Harp seals feed on a variety of crustaceans (decapods, amphipods, and euphausiids) and pelagic fish (capelin and herring) while migrating in the spring and fall and during the winter months prior to pupping (Jefferson et al. 1993; Reeves et al. 1992). While on the high latitude summer feeding grounds, the seals eat arctic and polar cod as well as several species of bottom dwelling fish, including redfish and Greenland halibut. Juveniles and newly weaned pups feed predominately on capelin and krill (euphausiids) and it is thought that harp seals fast while molting (Riedman 1990; Wynne and Schwartz 1999).

Status

Historically, Native peoples of the Canadian Arctic and Greenland hunted harp seals for subsistence purposes. Hunting continues today (as many as 10,000 animals each summer), but the number of animals that can be taken is regulated. Since the late 18th century, harp seals have been commercially hunted in the North Atlantic for fur, oil, and leather (Reeves et al. 1992). With the exception of commercial whaling, the commercial hunt for harp seals (particularly pups that were clubbed in large numbers for their white coats) was probably the most highly publicized form of marine mammal exploitation. Between 1950 and 1970, the western Atlantic stock of harp seals was reduced by 50 percent, from nearly 3 million to 1.5 million, as the result of intensive subsistence and commercial hunting. Today, commercial hunting of harp seals continues on a reduced scale as the result of Federally imposed quotas that limit the number of animals that can be killed each year (Jefferson et al. 1993). There are an estimated 3 to 4 million harp seals in the North Atlantic, and it is thought that this number is increasing.

FACTORS AFFECTING MARINE MAMMAL AND SEA TURTLE POPULATIONS

A variety of anthropogenic and natural factors are responsible for the overall decline of populations of marine mammals and sea turtles around the world. These factors detrimentally affect both the animals and the habitats in which they live.

Anthropogenic Factors

Aboriginal and subsistence hunting

Historically, subsistence and aboriginal hunting of marine animals was practiced worldwide. The hunting of these animals for human use severely impacted the populations. Coastal aboriginal people from all regions of the world have exploited marine mammals for centuries. The hunts are considered a

major cultural event and serve as an important source of food, clothing, equipment, shelter, and oil used for lighting and cooking (Lavigne and Kovacs 1988). Traditionally, many pinnipeds, including walruses, harp, hooded, and ringed seals, and cetaceans, including narwhals, harbor porpoises, and beluga, right, gray, and bowhead whales were hunted (Berta and Sumich 1999; Mulvaney 1996; Riedman 1990). The impact of aboriginal hunting pressure on marine mammal populations was typically localized and small in scale compared to later industrialized commercial hunting.

Subsistence hunting continues today, but regional and international quotas that provide for sustainable populations regulate most activities. The International Whaling Commission (IWC), the organization responsible for regulating hunts and conserving whale stocks globally, establishes recommended quotas for aboriginal subsistence whaling at the request of member nations (MMC 1998). Quotas for protected stocks are set at a level that should allow the stocks to recover while meeting the needs of the affected native communities and villages. For example, quotas have been set for subsistence hunting of northern fur seals on the Pribilof Islands, gray whales in Washington state, and harbor seals, Steller sea lions, bowhead whales, and the Pacific walrus in Alaska (Berta and Sumich 1999; MMC 1998; NMFS 1998b). Provisions of the MMPA allow natives to take marine mammals for subsistence purposes provided the harvest is not wasteful. As the result of management practices, the number of animals harvested for subsistence purposes in the United States has steadily decreased in recent years, allowing some populations of marine mammals to begin to recover.

Persistent overexploitation of sea turtles, especially adults, for the harvesting of meat, shells, oil, and skin is largely responsible for the depleted populations of sea turtles worldwide (Eckert 1995). Turtle meat is a favored food item in Mexico, several countries in South America, the Caribbean, Africa, and the Mediterranean (Ross 1995), and eggs are harvested universally for local consumption and commercial sale (Pritchard 1995). In some countries harvested sea turtles are used in soup and for the production of leather and cosmetics. The international trade of these products has played a prominent role in the depletion of sea turtle populations (Hill 1979). For example, nesting populations of leatherback sea turtles along the Pacific coast of Mexico have declined at an annual rate of 22% since 1987. The collapse of these nesting populations is believed to be the result of intensive overharvesting of eggs and the direct harvest of adults (NMFS 1999). Most countries forbid the taking of eggs, but enforcement is negligent, poaching is rampant, and the eggs can often be found for sale in local markets. Excessive removal of leatherback eggs has resulted in population declines on the west coast of India, Ceylon, Thailand, and Malaysia, and to an unknown extent in the Dominican Republic, Mexico, and Trinidad (Ross 1995). Turtle products, such as jewelry made from hawksbill shells, also create a threat to sea turtles. There is convincing evidence that hawksbill populations in the Atlantic were greatly depleted during the twentieth century as a result of overharvesting for trade in products made from their shells (NMFS 1999). The lack of information about the status of sea turtles leads many Americans to unwittingly support the international trade in these endangered species. Buying and selling turtle products within the United States is strictly prohibited by law, but turtle shell jewelry and souvenirs are the most frequent contraband seized by customs officials from tourists returning to the United States from the Caribbean. Indirect threats are harder to quantify, but they are likely causing the greatest harm to sea turtle survival.

The exploitation of sea turtle populations in other countries has an adverse effect on the number of turtles nesting on beaches in the southeastern United States. A number of countries have established conservation programs that are intended to protect sea turtle populations, particularly nesting females. For example, loggerhead nesting locations are protected in the United States, Australia, Mexico, and South Africa (Ross 1995). The almost exclusive nesting beach of the Kemp's ridley in Tamaulipas, Mexico is strictly protected and the turtle population there is in the earliest stages of recovery (NMFS 1999). However, the unregulated subsistence hunting of sea turtles and their eggs that persists in many countries will continue to contribute to the overall decline of these species.

Fisheries

Most species of marine mammals and sea turtles interact in some way with commercial fisheries, often resulting in their death. These animals may be disturbed, harassed, injured, or killed either accidentally or deliberately during fishing operations (MMC 1998). Interactions with fisheries represent some of the most significant threats to marine mammal and sea turtle populations globally. In addition, overharvesting of some fish stocks for commercial purposes may cause significant changes in prey species composition or reduce the availability of important prey for marine mammals and sea turtles. Either may lead to a shift in predator distribution or primary food source or an increase in mortality (MMC 1999; Payne et al. 1990; Weinrich et al. 1997). For example, Steller sea lion abundance has declined dramatically throughout most of the central and western part of its range over the past 30 years (MMC 1999). The cause of the decline is uncertain, but is thought to be the result of a decrease in the abundance of available prey species or a significant change in prey species composition due to overharvesting by large commercial fisheries in the area. As a result of this decline, the Steller sea lion was listed as threatened under the ESA in 1990.

Marine mammals and sea turtles are caught and killed in fishing operations utilizing a variety of gear types, including trawls, seines, gill nets, long lines, pound nets, purse seines and pots. The animals may swim into and become caught in a net, become trapped in a net during towing or retrieval, become ensnared in mooring or pot lines, get caught on hook and line gear, or may be injured or killed by fishermen in the process of attempting to release them from nets (Young et al. 1993). Lost and discarded fishing gear also poses a serious problem to marine mammals and sea turtles, who may accidentally swim into the gear and become entangled or trapped ("ghost fishing") (Berta and Sumich 1999; Laist 1995). Entanglement records indicate that all but one of the world's eight sea turtle species, 58% of the world's pinniped species, 8% of toothed whale species and 60% of baleen whale species have been entangled in marine debris, particularly lost fishing gear such as trawl net, gill net and monofilament line (Laist 1995). The result of this entanglement can be severe injury or death.

A variety of commercial fishing gears are utilized in Maryland waters, including gill nets, trawls, long lines, pound nets, seines, pots, and dredges. Each gear type is subject to state laws and regulations concerning deployment, seasonality, permitted catch (quotas), legal areas of use, and license or permit requirements. Several of these fisheries have reported incidental takes of marine mammals and sea turtles.

Gill nets

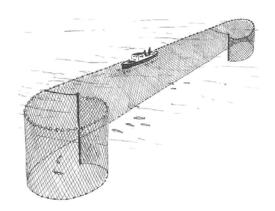
Gill nets are vertical walls of netting usually set in a straight line. They are designed to capture fish that attempt to swim through them by either entanglement (held by teeth, spines, or other protrusions without penetration of the mesh), wedging (held by mesh around the body) or gilling (held by mesh slipping behind the gills) (Hubert 1983). The net consists of a single sheet of webbing, typically constructed of monofilament nylon, with a buoyant float line at the top and a weighted lead line at the bottom (Read 1996). The nets may be set near the surface of the water, midwater, or on the bottom; the mesh size and depth is dependent upon the target species (Young et al. 1993). There are two types of gill nets, drift nets and set nets. A drift net is free floating (allowing it to move with the current) and usually drifts along the bottom, although it can be set at the surface or midwater. Each end of the net is buoyed. The net is tended by a fishing vessel and is periodically lifted and the fish are removed. Set nets are fixed in the water with anchors or stakes that have been pushed or pumped into the bottom (Casey 1999). Nets set close to shore are usually placed perpendicular to the beach and often stretch to the bottom to target bottom-dwelling species (Young et al. 1993).

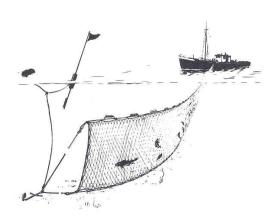
Drift gill nets are used to catch a variety of fish in the Chesapeake Bay, including Atlantic croaker, blue-fish, river herring, spot, striped bass, weakfish, and white perch. Gill nets are used to catch bluefish, smooth and spiny dogfish, American shad, striped bass, tautog, and weakfish in inshore and offshore

waters along the Maryland Atlantic coast. Anchored and stake gill nets are banned in the Maryland portion of the Chesapeake Bay; only the drift gill net is legal for this use (Casey 1999). In the Bay, the commercial drift gillnet fishery is subject to seasonal restrictions, quotas, and required permits (COMAR 08.02.05.02). Fishermen utilizing gill nets must attend the nets at all times (licensee remains within 2 miles of the net while it is in the water) and nets may be subject to mesh size and total length restrictions. In the Atlantic Ocean, the fishery is also subject to seasonal restrictions and quotas. In 2000, the gill net fishery in Maryland (which includes sink, anchor, and drift nets) landed an estimated 1,490.7 metric tons (\$2,853,685) of fish, crustaceans, and shellfish¹. Two of the gill net fisheries (Atlantic croaker and striped bass), which operate in the Chesapeake Bay and the Atlantic Ocean, have reported bycatch of protected species, including sea turtles and Atlantic and shortnose sturgeons².

DRIFT GILL NET

ANCHOR GILL NET





*Illustrations taken from Dumont and Sundstrom (1961).

Trawls

Trawls are bag-shaped nets that are towed horizontally or obliquely through the water column to collect fish by straining them from the water (Hubert 1983). As the net is towed, by either one or two vessels, fish enter the mouth or opening of the net and are trapped at the closed, or cod end. Weights and floats (otter trawl) or a rigid beam of wood or metal (beam trawl) are used to keep the net open vertically (Young et al. 1993). In order to spread the mouth of the net so that it will cover the largest possible area, each wing of the net is connected to a door, which is fitted with chains and attached to a towing cable from the trawling vessel. The resistance of the water against the boards forces the doors to pull in opposite directions, keeping the mouth of the net open (Casey 1999). A trawl can be used in various parts of the water column (surface, midwater or bottom), depending on the target species (Read 1996).

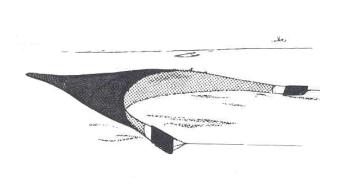
In Maryland, commercial trawling is prohibited in the Chesapeake Bay but occurs in inshore (0 to 3 miles) and offshore (3 to 200 miles) waters along the Atlantic coast. The fishery targets a variety of species, including Atlantic croaker, dogfish, weakfish, horseshoe crab, spot, and striped bass. In 2000, the otter trawl fishery in Maryland landed an estimated 609.7 metric tons (\$930,807) of fish¹. A person must obtain a license to operate a trawl (beam or otter) in the Atlantic Ocean and the individual cannot trawl within one mile of the Maryland coast (COMAR 08.02.05.03). The trawl fishery is also subject to quotas and seasonal restrictions. Several of the trawl fisheries, including those that target smooth and spiny dogfish, horseshoe crab, menhaden, and striped bass, have reported bycatch of protected species such as sea turtles and Atlantic and shortnose sturgeons².

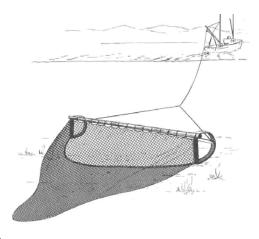
¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

OTTER TRAWL

BEAM TRAWL

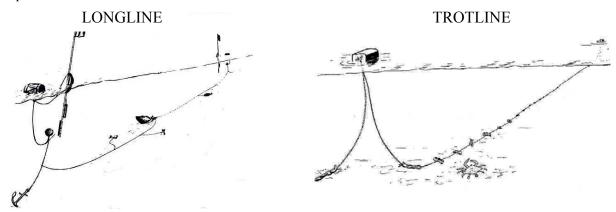




*Illustrations taken from Dumont and Sundstrom (1961).

Longlines and Trotlines

Longlines consist of a series of baited hooks attached to a long, horizontal line by short connecting lines. The hooks are spaced at regular intervals of a few feet. A line with a buoy is attached to each end to mark its position on the surface of the water. This type of fishing gear can be configured (using different hook sizes and fishing depths) to take a variety of fishes, including pelagic tuna and sharks. A trotline is similar to a longline except that bait is tied directly to the short lines (known as gangions or snoods) such that hooks are not used (Casey 1999). In Maryland, trotline is used in the Chesapeake Bay to catch blue crabs. The line fishery (long and trot) in Maryland landed an estimated 2,903.7 metric tons (\$8,371,876) of fish and crustaceans in 2000¹. The blue crab fishery is subject to seasonal and time restrictions as well as quotas.



*Illustrations taken from Dumont and Sundstrom (1961).

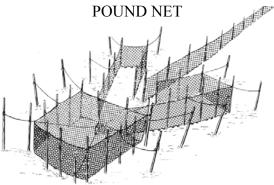
Fixed nets

Fixed nets, such as pound nets, hoop nets, fyke nets, and bank traps, are entrapment devices. Once in the net, a fish may move until it escapes, or it may pass through one or more funnel-shaped openings into additional compartments, thereby becoming entrapped. A pound net is an arrangement of fiber netting or chicken wire supported upon stakes or pilings with the head ropes or lines above the surface of the water. It consists of an enclosure (crib or pocket) with a netting floor that has two wings leading to and forming a heart-shaped net to aid in funneling fish into the crib. A long, straight net called a leader is attached to the heart. Its function is to lead fish off shore and towards the crib. Fish swimming along the shore are

¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

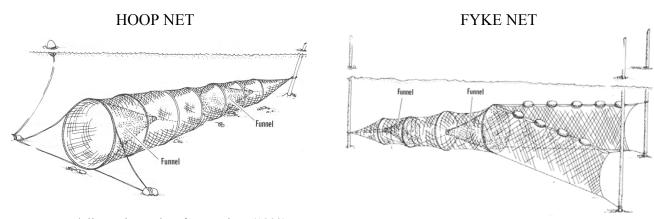
² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

turned towards the net by the leader, guided into the heart, and then into the crib where they become trapped (Casey 1999).



*Illustration taken from Dumont and Sundstrom (1961).

A hoop net is a cylindrical or conical net distended by a series of hoops or frames covered by web netting (Hayes 1983). The net has one or more internal funnel-shaped throats whose tapered ends are directed away from the mouth of the net to allow fish to enter the inner pot where they become trapped. Hoop nets are set by attaching a rope to an anchor or stake driven into the bottom at three locations; two at the opening of the net and one at the cod end of the net. Fyke nets are modified hoop nets with one or two wings or a leader of webbing attached to the mouth to guide fish into the net (Casey 1999; Hayes 1983). The net is set so that the wings and leader intercept the movement of the fish. When the fish follow the wing or leader in an attempt to avoid the enclosure they swim into the net. Typically, fyke nets are set in shallow water and the net and leader are set taut by anchors or poles driven into the bottom. A bank trap is similar to a pound net but is much smaller (usually 4 feet by 4 feet) and is used to catch blue crabs in the Chesapeake Bay. It consists of a rigid wood or metal frame and a single row of chicken wire hedging no longer than 75 feet in length (Casey 1999).



*Illustrations taken from Hubert (1983).

Fixed nets are used in the Chesapeake Bay to catch a variety of species, including Atlantic croaker, blue-fish, channel catfish, black drum, blue crabs, summer flounder, horseshoe crab, menhaden, yellow perch, striped bass, weakfish, white perch, and spot. Pound net sites in the Maryland portion of the Chesapeake Bay and its tributaries must be registered with the DNR. In 2000, the fixed net fishery in Maryland (including pound nets, fyke nets, hoop nets, and bank traps) landed an estimated 4,054.8 metric tons (\$4,007,944) of fish. Several of the fisheries utilizing fixed nets, including Atlantic croaker, black drum, spot, and weakfish, have reported bycatch of protected species such as marine mammals and sea turtles².

¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

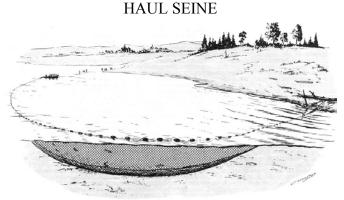
Seines

Seines are encircling nets used to surround large numbers of fish at or near the surface. Seines may be deployed from boats or along the shore. A purse seine is a large net with a buoyant float line at the top, a weighted lead line, and a rope or cable that runs through a series of rings along the bottom edge of the net ("purse lines"). A heavy skiff anchors one end of the net while another skiff (called the purse seiner) encircles the fish with the net. When the two boats meet, the net and purse lines are drawn tight, closing the bottom of the seine. The net can then be hauled on board. Purse seines are typically used to catch pelagic species, such as the yellowfin tuna, near the surface (Young et al. 1993).



*Illustration taken from Dumont and Sundstrom (1961).

Two types of seines are used in Maryland waters: the haul and beach seine. These seines are used in shallow water situations where the net extends from the surface to the bottom (Hayes 1983). A haul seine is an encircling type of net made of mesh webbing and consisting of two wings and a bag. The top line has floats to keep it at the surface and the bottom line is weighted. A haul seine is set to encircle any fish in the enclosed area. It is usually set from a boat and hauled to shore by hand or power winch or is bunted up in the water (Casey 1999). A beach seine is like a purse seine except that one end is anchored to shore and the net is run out into the water, parallel to the beach, and then dragged back towards shore, driving the fish to ashore (Read 1996). Haul and beach seines are used in the Chesapeake Bay to catch Atlantic croaker, spot, and striped bass. The seine fishery landed an estimated 80.6 metric tons (\$64,365) of fish in 2000^1 . It is subject to seasonal restrictions and permit and license requirements.



*Illustration taken from Sundstrom (1957).

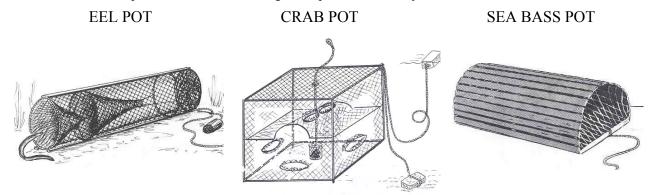
Pots and traps

Pots, which are often synonymous with traps, are cage-like structures (which vary in shape) that capture and hold fish, mollusks, and crustaceans. Bait, such as fish scraps and horseshoe crabs, are used to attract the target species. Typically, the pot has a funnel shaped opening that the target species must pass through to reach the receptacle containing the bait (Hubert 1983; Young et al. 1993). Pots are set singly or in lines and each trap is marked by a buoy. There are several types of pot gear, including lobster pots,

¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

crab pots, whelk pots, eel pots, and minnow traps (Hubert 1983). They are constructed from a variety of materials, including wire and steel mesh, plastic, wood slats, metal frames, and nylon netting (Casey 1999). Pots are used in the Chesapeake Bay to catch eels, channel catfish, and blue crabs and in the Atlantic Ocean to catch Black Sea bass, lobster, tautog, and whelk. The pot and trap fishery landed an estimated 8,094.7 metric tons (\$22,872,681) of whelk, blue crabs, terrapins, eels, fish, and lobsters in 2000¹, with the blue crab fishery comprising the largest percentage of the catch. The fishery is subject to seasonal and time restrictions and some types of pots are required to install an unobstructed escape panel of specified dimensions to reduce bycatch (e.g., eel and black sea bass pots; COMAR 08.02.05.08). There have been several reports of sea turtles entangled in pot lines in Maryland waters.



*Illustrations taken from Dumont and Sundstrom (1961).

Dredges

Dredges are frame-supported box- or bag-shaped devices used to sample benthic organisms when dragged over the bottom. They are usually equipped with blades, rakelike teeth, or hydraulic jets to scrape or dig into the substrate. Several variations of dredges are used in Maryland waters to catch crabs, clams, and oysters, although horseshoe crabs, sea scallops, and conch are also harvested. A crab scrape is a lightweight dredge typically operated in shallow waters of a bay or river. It has a rectangular metal frame to which a baglike pocket of webbing or wire netting is attached (Casey 1999). The scraper bar, which does not have teeth, is a flat blade designed to skim the substrate and deflect epibenthic organisms upward into the bag or pocket. The scrape is used to catch blue crabs in the Chesapeake Bay (Hayes 1983). The common dredge consists of a metal triangular or oblong frame, to which a net made of iron rings, Shooks, and cotton cording is attached (Casey 1999). The frame is equipped with a scraping bar with rakelike teeth on the lower edge. This equipment is used to gather oysters, crabs, and scallops, although crab dredges are not permitted in the Chesapeake Bay except for Maryland DNR blue crab monitoring projects (Casey 1999). In Maryland, oyster dredges can only be towed by a Skipjack during certain times of the year. In addition, the device is limited to 42 to 44 inches as measured along the scraper bar and cannot exceed 200 pounds in weight (Casey 1999).

CRAB SCRAPE

OSYTER DREDGE



*Illustrations taken from Dumont and Sundstrom (1961).

¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

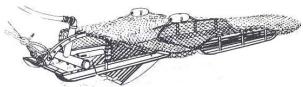
² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

A hydraulic or jet dredge is used to catch surf, soft, and hard clams and sea scallops. The hydraulic soft and hard clam dredge consists of a bank of water jets located in a cutting assembly in front of an escalator type conveyor belt. The device is attached to the side of a vessel, lowered to the bottom, and pushed forward. A high powered pump on the vessel supplies pressurized water to the jets, which erode the sediment and wash the clams out of the bottom and onto the conveyor belt, which brings the clams up the vessel (Casey 1999; Hayes 1983). In deeper water, surf clams and sea scallops are harvested using a similar hydraulic dredge, but a collecting bag replaces the conveyor belt. The structure has an adjustable cutting blade that cuts a trench in the bottom as the dredge is dragged forward. The substrate is plowed upward into the dredge and pressurized water pumped through a hose and nozzles washes the sediment from the clams. The hydraulic force of water passing through the dredge moves the clams and scallops into a collecting bag made of steel rings (Hayes 1983). Hydraulic surf clam dredges are used in the Atlantic Ocean, generally no more than 20 miles offshore of the Maryland coast. The hydraulic soft clam dredge is used in Maryland's Chesapeake Bay and is set to dig as deep as 18 inches into the substrate. The same dredge, set to dig no more than 6 inches into the substrate, is used in the coastal bays to collect hard clams (Casey 1999). The dredge fishery (including scrapes) landed an estimated 3,388.1 metric tons (\$6,386,534) in 2000¹. The fishery is subject to seasonal, geographical and time restrictions, quotas and permit and license requirements.

HYDRAULIC OR JET DREDGE, HARD/SOFT CLAM

HYDRAULIC OR JET DREDGE, SURF CLAM





*Illustrations taken from Dumont and Sundstrom (1961).

Fisheries Interactions

The incidental mortality of marine mammals and sea turtles in commercial fisheries has been documented globally. Marine mammals, such as large whales and pinnipeds, have been incidentally captured in almost all major gear types, including gill nets, trawls, purse seines, trammel nets, longlines, trotlines, traps, and pots (Alverson et al. 1994; Jefferson and Curry 1994; Morizur et al. 1999; Read and Gaskin 1988; Wynne and Schwartz 1999; Young et al. 1993). The largest marine mammal bycatch appears to occur in various drift- or gill nets and tuna seine fisheries (Alverson et al. 1994). One of the best known and best-documented examples is the incidental take of dolphins by the Eastern Tropical Pacific (ETP) purse seine tuna fishery. In the late 1950s, purse seiners began setting nets around schools of dolphins in order to catch large vellowfin tuna that tended to associate with the dolphins (Hofman 1990). In the process, dolphins became entangled and drowned in the nets before they could be released. Throughout the 1960s and into the early 1970s, the United States fleet dominated this fishery and was responsible for more than 80 percent of the dolphin mortality (Young et al. 1993). Based in part on kill per set and fishing effort data provided by the NMFS and the Inter-American Tropical Tuna Commission, it has been estimated that more than 6.5 million dolphins were killed in the ETP between 1959 and 1997 (Gosliner 1999; MMC 1998). The death of dolphins in the tuna fishery emerged as one of the key concerns that led to the enactment of the MMPA in 1972.

The incidental take of small cetaceans, particularly porpoises, seems common in many gill net fisheries and has been documented extensively. For example, in the mid-1950s as many as 10,000 to 20,000 Dall's

¹ Data source: Fisheries Statistics and Economics Division, NMFS (www.st.nmfs.gov/st1/commercial)

² Data source: Atlantic States Marine Fisheries Commission Fisheries Characterization Database, October 18, 1999.

porpoises drowned in the Japanese salmon drift-net fishery in the North Pacific (Jefferson and Curry 1994); forty thousand or more cetaceans are killed annually in gill nets set in the coastal waters of Sri Lanka (Dawson 1991); more than 25,000 small cetaceans, including Atlantic white-sided dolphins and harbor porpoises, may have been caught in gill net fisheries along the coast of Newfoundland in 1980 (Hofman 1990); and the estimated total incidental catch of harbor porpoises in the United States Gulf of Maine groundfish gillnet fishery in 1990 and 1991 was 4,100 individuals (Hutchinson 1996).

Information about the numbers of seals, sea lions, and other marine mammals incidentally taken in commercial fisheries is less quantifiable than for small cetaceans. In certain areas of the world, significant interactions have been documented between fisheries and Steller sea lions, northern fur seals, harp seals, gray seals, Mediterranean monk seals, harbor seals, New Zealand fur seals, pilot whales, common dolphins, the Caribbean manatee, and the dugong (NMFS 1995; Northridge 1984).

Some species of marine mammals may survive the initial contact or interaction with fishing gear, but ultimately suffer indirect effects related to the entanglement. For example, large marine mammals, particularly humpback and right whales, become entangled in gill nets, longline, and pot and trap lines. Kraus (1990) found that 57% of documented North Atlantic Right whales possessed scarring indicative of entanglement and that 4.3% of the time these entanglements were fatal. Observations indicate that entangled animals may carry or trail gear for long periods of time and over long distances. In some instances marine mammals may eventually free themselves of the gear, but the long-term effects of the release from entanglement are unknown (Angliss and DeMaster 1998). In many cases a whale disentanglement team attempts to remove the gear from an entangled animal or the animal dies as a direct result of the entanglement. Indirect effects are also possible. For example, fishing line wrapped around the body and flippers may compromise an animal by causing lacerations and impeding mobility or feeding, which may make the animal more susceptible to disease, starvation, or predation (Angliss and DeMaster 1998). Another possible effect is capture myopathy, a potentially fatal condition caused by strenuous exercise, fear, overexertion, exhaustion, and hypothermia. It is common during the pursuit, capture and transportation of wildlife, but may occur in marine mammals as the result of a struggle to free themselves from entanglement in fishing gear (e.g., dolphins captured in tuna purse seines in the Eastern Tropical Pacific). Within a few hours to several days after release, these animals may suffer from depression, stiffness, weakness, incoordination, muscular tremors, recumbency, paralysis, collapse, and death (Chalmers and Barrett 1982).

Human related injuries to marine mammals and sea turtles also occur as the result of intentional harm. Some fishermen view marine mammals, particularly pinnipeds along the United States Pacific coast, as competition for shared food resources and shoot or poison them (Angliss and DeMaster 1998; MMC 1998). Mediterranean monk seals, California sea lions, Steller sea lions, and harbor seals are among the many species that have been documented with gunshot wounds (Young et al. 1993). The most common human-related injury of pinnipeds rescued and rehabilitated at the Marine Mammal Center in Sausalito, California is gunshot wounds. Between 1994 and 1996, gunshot wounds were identified in 7% of the examined stranded animals brought in for rehabilitation. Typically, only about 10% of animals that are shot survive to be released back into the wild (Angliss and DeMaster 1998).

In Maryland, dead stranded marine mammals have been observed with signs of fisheries interactions including net marks (linear depressions on appendages, head, and body), severed appendages, and entanglement in monofilament line or rope around the head, flippers, peduncle or flukes. Stranding data collected in Maryland between 1990 and 1999 indicate that approximately 38% of marine mammal strandings were probable fisheries interactions. However, in some cases the state of decomposition of an animal precludes definitive confirmation of a fisheries interaction. Therefore, the numbers should be taken as estimations of fisheries related mortality. Bycatch data collected off the coast of Maryland by the NMFS National Observer Program indicated that 29 marine mammals were incidentally captured in

commercial fishing gear between 1994 and 1999 (Mike Tork, NOAA, personal communication). Observations were made between thirty and fifty days out of a year and were almost exclusively on gill net boats. Six marine mammals were captured alive in the pelagic longline fishery (one Risso's dolphin and five pilot whales). Several of these animals were observed with gear wrapped around the mouth, flippers or body. Five marine mammals were observed dead in the bottom otter trawl fishery (three common dolphins and two pilot whales), twelve marine marines were observed dead in the coastal bottom gill net fishery (two common dolphins, eight harbor porpoises and two unidentified cetaceans) and six harbor porpoises were observed dead in the coastal drift gill net fishery. As mentioned earlier, bycatch data reported by commercial fishermen in Maryland indicate that the fixed net fishery, which operates in the Chesapeake Bay, incidentally captures marine mammals. Despite this data, the magnitude of marine mammal mortality due to commercial fisheries in Maryland is largely unknown.

Commercial fishing activities have been documented as one of the largest sources of sea turtle mortality. Sea turtles can become caught or entangled in trawls, pot and trap lines, gill nets, pound nets, longlines, weirs, and trammel nets (Anonymous, 1996; Balazs 1982; Caillouet et al. 1996; Lutcavage et al. 1997; NRC 1990; Renaud et al. 1997; Witzell 1999). The incidental capture of sea turtles in United States shrimp trawls is believed to be the single largest source of mortality of juvenile and adult sea turtles. In fact, it accounts for more mortality than all other sources of human activities combined (Lutcavage et al. 1997; NMFS & USFWS 1991). All five species of sea turtles found along the United States Atlantic coast and Gulf of Mexico (loggerhead, Kemp's ridley, green, hawksbill and leatherback sea turtles) have been captured in shrimp trawls (Renaud et al. 1997). Before the implementation of protective measures such as Turtle Excluder Devices (TEDs), as many as 5,000 to 50,000 loggerheads and 500 to 5,000 Kemp's ridleys drowned in United States shrimp trawls annually (Lutcavage et al. 1997; NRC 1990). Another estimation of sea turtle mortality indicated that 9,874 loggerheads, 767 Kemp's ridleys and 229 green sea turtles died annually in shrimp trawls between 1973 and 1984 (Renaud et al. 1997). In 1978 the NMFS and Sea Grant Program undertook development of trawl modifications (TEDs) that would allow captured turtles to escape the trawl through an hatch in the top of the net (Lutcavage et al. 1997). By 1994, all United States shrimpers from North Carolina to Texas were required to use certified TEDs year round. Despite TED regulations, entanglement in trawls remains a primary source of mortality for some species of sea turtles and is hindering their recovery (e.g., Kemp's ridley; Wynne and Schwartz 1999).

In Maryland, stranded sea turtles have been observed with a missing head or flippers, fishing gear such as hook and line in the esophagus, stomach, or intestines, and line or rope entangled around the flippers. Stranding data collected between 1990 and 1999 indicate that approximately 4.3% of sea turtle strandings in Maryland are probable fisheries interaction. However, the moderate to advanced state of decomposition of most sea turtle carcasses may make evidence of a fisheries interaction (e.g., linear depressions, severed flippers) difficult to assess. Therefore, these numbers are at best estimations of fisheries related mortality. Bycatch data collected off the coast of Maryland by the NMFS National Observer Program indicated that twelve sea turtles were incidentally captured in commercial fishing gear between 1994 and 1999. Observations were made between thirty and fifty days out of a year and were almost exclusively on gill net boats. Five sea turtles were captured alive in the pelagic longline fishery (four loggerheads and one leatherback). The leatherback and two of the loggerheads were observed entangled in fishing gear. Two loggerhead sea turtles (one alive, one dead) were captured in the coastal bottom otter trawl. Five sea turtles were incidentally captured in the coastal bottom gill net fishery (two loggerheads and two unidentified sea turtles, alive; one unidentified sea turtle, dead). One of the turtles was observed with gear in and around its mouth. As mentioned earlier, bycatch data reported by commercial fishermen in Maryland indicates that several fisheries, including trawls (inshore and offshore), gill nets (Chesapeake Bay, inshore and offshore) and fixed nets (Chesapeake Bay) incidentally catch sea turtles. However, the magnitude of mortality due to these fisheries is largely unknown.

Pollution

Marine mammals and sea turtles can be directly and indirectly affected by a variety of environmental pollutants. These include chemical contaminants such as organic compounds and toxic metals from point and non-point sources, marine debris, oil spills, and harmful algal blooms.

Chemical Pollution

It is probable that most marine mammals and sea turtles have been exposed to a variety of chemical compounds introduced directly into the marine environment by human activities or indirectly through dispersion via food webs. Most marine mammals (except the sirenians and some baleen whales) and sea turtles are predators that feed high in the food chain, making them susceptible to biomagnification or bioaccumulation of toxins and other pollutants. Typically, animals at the top of the food chain have the highest residue levels of pollutants, especially organochlorines (OCs) (Reddy et al. 1998). OCs are known to bioaccumulate in the marine food web such that whales are reported to contain concentrations 100 times those found in fish, whereas fish in turn contain concentrations 1,000 times those in plankton. The blubber layer found in most marine mammals is an ideal repository for the accumulation of pollutants (Ridgway and Reddy 1995).

The levels of organochlorine compounds, particularly polychlorinated biphenyls (PCBs), pesticides such as dichloro-diphenyl-trichloroethane (DDT), and heavy metals, including mercury, lead, and copper, were studied in a variety of marine mammal species around the globe. These studies include bottlenose dolphins along the United States Atlantic coast and Gulf of Mexico (Kannan et al. 1997; Kuehl and Haebler 1995), sperm whales in the southern North Sea (Holsbeek et al. 1999), harp seals in the White Sea (Kleivane et al. 1997), a variety of baleen whales in the northwest Atlantic (Gauthier et al. 1997), Caspian and harbor seals in the Caspian sea (Hall et al. 1999), and minke whales in the northeast Atlantic (Kleivane and Skaare 1998). The results of these studies showed high levels of contaminants (both OCs and metals) in a number of species, particularly bottlenose dolphins, harbor porpoises, and several species of seals (Hall et al. 1999; Jefferson et al. 1993; Kuehl and Haebler 1995; Law et al. 1992; Mössner and Ballschmiter 1997; Wynne and Schwartz 1999). In addition, marine mammals in the western North Atlantic showed significantly higher levels of OCs than animals from other regions of the world (Mössner and Ballschmiter 1997). A correlation exists between the total contaminant burden and the position of a marine mammal in the food chain. Seals and toothed whales, which are predatory animals at the top of the food web, have a higher contaminant load than the most of the filter-feeding baleen whales, which feed at a lower trophic level (Clapham et al. 1999; Mössner and Ballschmiter 1997).

Historically, the highest levels of OCs in marine mammals were found in the blubber, liver and milk (Ridgway and Reddy 1995). In many of the species studied, mature males tended to have higher concentrations of pollutants than mature females and juveniles of both sexes (Gauthier et al. 1997; Kleivane and Skaare 1998; Kleivane et al. 1997; Kuehl and Haebler 1995; Ridgway and Reddy 1995; Woodley et al. 1991). In fact, the level of OCs in reproductively active females generally decreases or plateaus with age, while the level in males increases with age (Ridgway and Reddy 1995). During lactation, OCs are transferred to the calf, thus lowering maternal levels. It is only through the process of lactation that much of the contaminant burden of females is reduced, which explains why these levels do not continue to increase in reproducing females of many marine mammal species (Ridgway and Reddy 1995). The possible effects of OCs on the health of marine mammals include a decrease in reproductive efficiency, reproductive failure, developmental disorders, altered endocrine physiology, cancer, skin tumors, and immunosuppression (Aguirre et al. 1994; MMC 1998; Reddy et al. 1998; Reijnders and Lankester 1990).

Although sea turtles are also susceptible to chemical contaminants and biomagnification, few toxicological studies have been published regarding the concentrations of such compounds in these animals. The eggs and tissues of several sea turtle species from various geographic regions were analyzed for OCs, heavy metals, hydrocarbons, and radionuclides. The level of contamination varied among studies and

species (Aguirre et al. 1994; Clark and Krynitsky 1985; McKim and Johnson 1983; Thompson et al. 1974; Witkowski and Frazier 1982). For example, analysis of the level of OCs in loggerhead and green turtle eggs and liver and muscle tissues from subadults indicated the presence of low levels of PCBs and DDE, a breakdown product of DDT (Clark and Krynitsky 1980; Hillestad et al. 1974; McKim and Johnson 1983). However, loggerheads consistently had higher concentrations of PCB and DDE than green turtles, indicating that not all sea turtles accumulate residues at the same rate (George 1997). This variation may be due to dietary differences and bioaccumulation in the food chain. Loggerheads are generally carnivorous throughout their life, while greens are omnivorous, feeding primarily on plants as adults (Ernst and Barbour 1989). A study on the distribution of organochlorine pollutants in the tissues of Kemp's ridley and loggerhead sea turtles collected primarily from the lower Chesapeake Bay found a wide range of concentrations of PCBs, DDT, and its breakdown products (DDE and DDD) in the two species (Rybitski et al. 1995). The high degree of variation may be explained by the condition of the animal at the time of analysis and exposure to contaminants. Both species migrate over long distances and, as a result, exposure of individual animals may vary with habitat. Some animals may feed in contaminated areas while others feed in more pristine areas. Ingestion is the probable route of exposure to contaminants in these turtles. Sources of contamination include polluted prey and incidental ingestion of sediments during benthic feeding. Juvenile loggerheads and Kemp's ridleys migrate into the Chesapeake Bay during the late spring and summer months, where they feed primarily upon horseshoe crabs and blue crabs, respectively (Lutcavage and Musick 1985). Contaminants such as alkylated polycyclic aromatic compounds (PACs), polynuclear aromatic hydrocarbons (PAHs), and PCBs, have been documented in the aquatic biota and sediments of the Chesapeake Bay and may be a source of contamination for sea turtles during the summer months (Hale 1988; Rybitski et al. 1995).

While it is clear that sea turtles accumulate organochlorine compounds, the concentration of contaminants is usually several orders of magnitude lower than those found in marine mammals (Davenport and Wrench 1990; George 1997; Hutchinson and Simmonds 1992). The physiological effects of these compounds in sea turtles are unknown, but may be similar to those documented in marine mammals. Pollutant-mediated stress has been shown to cause morphophysiological changes such as skin tumors in aquatic organisms. However, the results of one study indicate that there is no correlation between pollutants, specifically organochlorines and heavy metals, and the presence of green turtle fibropapillomas (GTFP), a tumor-producing epizootic disease affecting several sea turtle species, particularly the green sea turtle, *Chelonia mydas* (Aguirre et al. 1994; George 1997).

Marine Debris

The disposal and loss of debris into the world's oceans has become a significant form of marine pollution. The term encompasses a variety of materials, including plastic bags, plastic strapping bands, discarded fishing nets, synthetic rope and line, plastic 6-pack yokes, raw plastic pellets, glass bottles, metal cans, lumber, and cigarette butts (Hutchinson and Simmonds 1992; Laist et al. 1999). The sources of marine debris are both land- and sea-based. Land-based sources include industrial outfalls, sewage, and storm drains, beachgoers, coastal dumps, and upland runoff into rivers and bays. Watercraft (e.g., cargo, commercial fishing, military, passenger, recreational, and jet skis) and offshore platforms are the principal at-sea sources of marine debris (Laist et al. 1999). Plastics are the most abundant type of marine debris found on the beach and in the oceans. It is estimated that 24,000 metric tons of plastic packaging is dumped into the ocean every year (NRC 1990) and that 53 to 64 percent of beach debris in the United States is made of plastic (Laist et al. 1999). An estimated 100,000 sea turtles and marine mammals die from ingestion of or entanglement in plastic debris each year (NRC 1990).

Animals that become entangled in the loops and openings of marine debris may exhaust themselves and drown, reduce or lose their ability to catch prey and avoid predators, or sustain wounds and infection caused by debris abrasion or constriction (Laist et al. 1999; MMC 1998; Wallace 1985). Entanglement in derelict fishing gear is a serious problem for sea turtles. The vast majority of entanglements involve

monofilament line and nets (from commercial and recreational fishing), rope, and commercial trawl and gill net webbing (Balazs 1985; Laist 1997). Based on sea turtle stranding records collected from 1980 to 1992 along the Atlantic coast of the United States and the Gulf of Mexico, entangling debris was found on 0.8% (142 of 16,327) of loggerhead turtles, 6.6% (123 of 1,874) of green turtles, 6.8% (66 of 970) of leatherback turtles, 14% (36 of 258) of hawksbill turtles, and 0.8% (18 of 2,140) of Kemp's ridley turtles (Laist et al. 1999). For marine mammals, entanglement in marine debris is most common among the pinnipeds, particularly fur seals, and less common in baleen whales, toothed whales, and manatees (Laist 1997). Studies of the northern fur seal herd on the Pribilof Islands suggest that in the late 1970s as many as 50,000 juvenile fur seals became entangled in marine debris and died each year. This population has failed to recover, suggesting that entanglement is still a significant source of mortality (MMC 1998). Scars indicative of rope and line entanglement have been identified on 57% of photographed northern right whales in the western North Atlantic and 12% of documented mortality from 1970 to 1989 was attributed to entanglement in fishing gear (Laist 1997; Laist et al. 1999). Entanglement has been identified as a major source of mortality for this endangered species and is contributing to the continued decline of western North Atlantic population.

Ingestion of marine debris can cause intestinal blockage or irritation, reduced nutrient absorption, reduced food intake due to a false sense of satiation, localized necrosis, suffocation, ulceration, physical deterioration, malnutrition, and starvation (Laist 1999; NRC 1990). As a result, animals may become weakened and thus more susceptible to predators and disease and less fit to successfully reproduce (Hutchinson 1996). Sea turtles may be predisposed to ingestion of marine debris because they are indiscriminate feeders and often mistake floating plastic bags and sheets for jellyfish and other prey (Fritts 1982). Ingestion of marine debris has been documented in six of the seven sea turtle species (Lutcavage et al. 1997; MMC 1998; Wallace 1985). Analysis of the stomach contents of stranded sea turtles along the United States Atlantic coast and Gulf of Mexico between 1980 and 1992 revealed ingested materials such as plastic bags and pieces of rubber in 44% (8 of 18) of hawksbill turtles, 13% (15 of 115) of leatherback turtles, 6.9% (18 of 262) of green turtles, and 6.6% (59 of 896) of loggerhead turtles (Laist et al. 1999). Examination of the digestive tracts of 51 sea turtle carcasses that washed ashore in Florida revealed that 49% of the turtles had ingested marine debris (Bjorndal et al. 1994). Based on stranding data collected from 1978 to 1988, the NMFS estimated that one-third to one-half of all sea turtles have ingested plastic products or byproducts (NRC 1990).

Although available data indicate that entanglement is a far greater threat to marine mammals than ingestion of marine debris, ingestion has been documented in several species of toothed whales, some pinnipeds, and the manatee (Cawthorn 1985; Kemp 1996; Laist 1997). For example, an examination of 439 stomachs collected from Florida manatees from 1978 to 1985 revealed that 63 (14.4%) contained ingested debris. In addition, a sample of 32 stomachs collected from pygmy sperm whales stranded along the United States Atlantic coast and Gulf of Mexico between 1971 and 1996 included 6 (18%) with ingested debris (Laist et al. 1999). In November 1993, the NAIB successfully rescued and rehabilitated a pygmy sperm whale that stranded on the New Jersey shore. The animal suffered from pneumonia, dehydration, a heavy parasite load, and muscle trauma when it arrived at the Aquarium. An endoscopic examination revealed that plastic debris, including the shredded remains of a mylar balloon, a trash bag, and other castoffs, had clogged the first of the animal's three stomachs, depriving its body of nourishment. It took six endoscopic procedures to remove the near-lethal collection of plastic trash from the stomach. Five months later the pygmy sperm whale had grown 14 1/2 inches and gained 125 pounds and was healthy enough to be released off the coast of Florida (D. Schofield, NAIB, personal communication). The Maryland stranding network has documented several cases of ingested marine debris in dead stranded marine mammals. For example, stranding network personnel at COL discovered a black plastic bag in the duodenum of a True's beaked whale that stranded in Delaware in 1991 and a thick, yellow rubber band resembling a lobster claw band in the stomach of a harbor porpoise that stranded in Maryland in 1998.

Oil spills

Before the Exxon Valdez oil spill in Prince William Sound, Alaska, in 1989, the effects of oil spills on marine mammals and sea turtles had received little attention. The spill occurred in an area rich with resources for marine mammals. An estimated 3,500 to 5,500 sea otters and 300 harbor seals (far more pinnipeds than had ever been documented in an oil spill) died in that event, leaving little doubt about the vulnerability of these species, and perhaps others, to the effects of oil (Geraci et al. 1999). Despite the widespread attention that oil spills have received since the Exxon Valdez, their impacts, particularly longterm, on marine mammals and sea turtles are still poorly understood. All marine mammals and sea turtles spend time at the surface, swimming, breathing, feeding, or resting, thereby enhancing the potential for contact with floating oil slicks. Interactions with the oil may foul fur, irritate skin and eyes, or result in inhalation of petroleum vapors, ingestion of oil or oil-contaminated food, and abandonment of polluted feeding habitats (Lutcavage et al. 1997; Neff 1990). Oil that comes ashore is likely to foul pinnipeds in nursery or haul-out areas and sea turtle eggs and hatchlings on nesting beaches. A coating of oil on the fur of a marine mammal reduces its insulative value by removing natural oils that waterproof the pelage. This results in greater heat loss and an inability to regulate core body temperature, which may eventually lead to death (St. Aubin 1990). Inhalation of toxic fumes can cause irritation of the respiratory membranes and airways. Ingestion of oil directly or by way of contaminated prey can cause subtle, progressive organ damage or acute death. For example, the hydrocarbons in oil can irritate or destroy cells in the lining of the stomach, affecting motility, digestion, and absorption of food (Clapham et al. 1999).

While an oil spill certainly adds an element of risk to the environment, and oil fouling has been implicated in the deaths of pinnipeds and otters, much of the evidence has been circumstantial. Incidental ingestion of oil during feeding, exposure to vapor concentrations that might be expected under natural conditions at sea, and limited surface fouling do not appear to cause significant stress in pinnipeds or cetaceans (Geraci 1990; St Aubin 1990). However, there is direct evidence that sea turtles have been seriously harmed and killed by oil spills (see Lutcavage et al. 1997 for review). Exposure to tar and oil can cause a host of changes and problems in sea turtles. Oil and tar have been found blocking the nasal cavity, mouth, and esophagus of hatchlings, resulting in starvation and death. These substances have also been found in the stomachs of post-hatchlings loggerheads in convergence fronts east of Florida (Hall et al. 1983; Heinz et al. 1992; Lutcavage et al. 1997). Ingestion of oil may interfere with intestinal function and possibly cause serious toxicity problems. In laboratory studies of juvenile loggerheads almost all of the major physiological systems were adversely affected by short-term exposures to weathered crude oil (Lutcavage et al. 1995, 1997). Changes in respiration rates, diving patterns, energy metabolism, and blood chemistry occurred. A four-fold increase in white blood cells indicated a rapid immune response following oil exposure, with a concurrent 50% reduction in red blood cell counts. The salt glands failed to produce fluids several days after exposure, although function returned within two weeks. Prolonged salt gland failure could have serious consequences for sea turtles as it interferes with water balance and ion regulation. Turtles also had acute contact dermatitis, or disruption of the architecture of the skin and mucous membranes. A break in the skin is of particular concern because it may increase susceptibility to infection (Lutcavage et al. 1995, 1997).

The Chesapeake Bay has been contaminated with oil on a number of occasions when accidents occurred during its transport. The largest oil spill in recent history occurred on April 7, 2000 at the Potomac Electric Power Company (PEPCO) Chalk Point Generating Station in Aquasco, Maryland, located at the confluence of Swanson Creek and the Patuxent River. Approximately 129,000 gallons of fuel oil leaked into Swanson Creek Marsh from a branch of the 51-mile underground pipeline that runs along the Patuxent River shoreline and feeds the plant. Wind and choppy tidal conditions spread the oil plume into the Patuxent River to ten miles south of the plant. The oil spill cleanup operation was a cooperative effort between the EPA, Maryland Department of the Environment (MDE), Maryland DNR, USCG, Pepco employees, and officials from other Federal, state, county, and local government agencies. Despite clean up efforts that collected 66,000 gallons of spilled oil, an estimated 30 percent of the oil soaked into the

45-acre marsh, which is a natural wildlife and fish habitat that contains sheltered tidal flats and freshwater marshes and swamps. The spill killed more than 400 birds, reptiles, fish, and mammals and injured hundreds more that were rescued, rehabilitated and released back into the area by the USFWS, the Maryland DNR and several animal rescue organizations. Initial precautionary measures temporarily closed shellfish beds, restricted boating, and advised against consumption of fish and crabs in that area. However the area was reopened to fishing and vessel traffic after laboratory tests conducted on fish, crabs, and shellfish harvested from the Patuxent River found that they were safe for consumption.

The current focus of the aftermath of the oil spill is on damage assessment and long-term restoration efforts. These efforts will involve continued monitoring of fish and wildlife in the affected area to determine the cumulative and physiological effects of oil on these species. In addition, long-term studies of the impacts of the oil spill on the aquatic and marsh habitats will also be important to the recovery of affected species. Although no marine mammal or sea turtle strandings were reported in the area during the time of the oil spill, there have been strandings in the Patuxent River and surrounding areas in years past. Therefore, the potential exists for these species to encounter oil spills in the Chesapeake Bay. As with the Exxon Valdez oil spill, the effects could be detrimental to endangered and threatened marine mammal and sea turtle populations utilizing the Chesapeake Bay.

Harmful Algal Blooms

Harmful algal blooms (HABs) occur in all coastal regions of the United States and are of national concern because of the adverse effects they have on human and marine organism health. The number and diversity of reported HABs has increased during the past 25 years and may continue to increase. Certain algae and protozoa, particularly dinoflagellates, produce toxins that can accumulate in fish and invertebrates and eventually poison predators higher up the food chain (Geraci et al. 1999). HABs can cause cell and tissue damage and mortality through a number of mechanisms, including toxin production, predation, particle irritation, induced starvation and localized anoxic conditions (Bushaw-Newton and Sellner 1999). As a result, HABs can affect a variety of living organisms in a coastal environment, from plankton to fish to people. A bloom occurs when algae or larger, multicellular species rapidly increase in numbers to the extent that they dominate the local planktonic or benthic community (Bushaw-Newton and Sellner 1999). Such a high abundance can result from the physical concentration of a species in a certain area due to local water circulation patterns that transport offshore populations to inshore regions (Bushaw-Newton and Sellner 1999).

HABs may also be exacerbated by human activities, particularly pollution from nutrient inputs. The most serious threat to the Chesapeake Bay is nutrient overenrichment, primarily nitrogen and phosphorus from point and non-point sources such as sewage discharge and hog and chicken farm overflows (Magnien 1998). An excess of nutrients disrupts the balance of the ecosystem, producing algal blooms that reduce water clarity and prevent light from reaching submerged aquatic vegetation (SAV) beds. Deposition and subsequent decomposition of large concentrations of plankton depletes dissolved oxygen in the Bay, resulting in localized anoxic conditions for fish, shellfish, or other species in the area (Blankenship 1997; Magnien 1998; Reshetiloff 1997). A HAB group common to the mid-Atlantic, particularly Maryland, is *Pfiesteria piscicida*, a toxic dinoflagellate that has been associated with fish lesions and fish kills in coastal and estuarine waters from Delaware to North Carolina. In addition, some algal species are common in the Chesapeake Bay and routinely occur in abundance at certain times of the year, resulting in algal blooms. One such species, *Prorocentrum minimum*, tends to bloom in the spring, producing "mahogany tides" as the result of the its reddish pigments that cause the water to have a brownish to mahogany hue. These algal blooms are enhanced by nutrients, light, temperature and water flow and cause low dissolved oxygen levels that often lead to fish kills.

HABs have been associated with the mortality of marine mammals in several coastal areas of the United States. A red tide outbreak in Lee County, Florida, resulted in the deaths of 39 manatees between Febru-

ary and March of 1982. The manatees appear to have died from incidental ingestion of filter-feeding tunicates that had accumulated the neurotoxin-producing dinoflagellates responsible for causing the red tide (O'Shea et al. 1991; USFWS 1995). In 1996, a HAB just south of Tampa Bay, Florida killed more than 150 manatees. A HAB off the coast of the Florida panhandle was believed to be responsible for more than 65 bottlenose dolphin moralities in 1999 (Bushaw-Newton and Sellner 1999). During 1987 and 1988, humpback whales in the southern Gulf of Maine appear to have been fatally poisoned from consumption of mackerel that contained high levels of saxitoxin, a dinoflagellate toxin (Geraci et al 1989).

Boating

In recent years there has been an increase in the number of boaters, both recreational and commercial, that utilize Maryland coastal waters and the Chesapeake Bay. There are more than 200,000 registered boaters in Maryland, as well as numerous visits by non-resident vessels each year. Marine mammals and sea turtles are susceptible to disturbance and injury by boats, especially in areas of high human population where recreational boat traffic is heavy and ports are active, such as the Chesapeake Bay. Large cetaceans, including right and humpback whales, are prone to collisions with ships, which often prove fatal (Clapham et al. 1999; Kraus 1990; Wiley et al. 1995). All marine mammals and sea turtles can be injured by boats and their propellers (Kraus 1990; NRC 1990; Wells and Scott 1997). For example, in the Chesapeake Bay region, boat-propeller wounds accounted for approximately 7% of stranded sea turtle deaths between 1979 and 1988 (or about five to seven turtles per year; NRC 1990). High and increasing numbers of Florida manatees die every year from collisions with watercraft; 1999 saw a record high of 82 fatalities. In Maryland, propeller wounds were identified as the probable cause of death in approximately 13% of sea turtles strandings from 1990 to 1999.

Recreational and commercial boat traffic also cause noise pollution, resulting in behavioral and acoustic disturbances of marine mammals and sea turtles. Boat traffic can disturb resting, feeding, migration, mating, calving, and social behavior of marine mammals and sea turtles, resulting in modifications of behavior (NMFS 1991a; Richardson et al. 1995; MMC 1998). Behavioral responses of marine mammals to approaching boat traffic include changes in respiration, surfacing, and diving cycles (decreased surfacing frequency and longer dives), increased swimming speeds, avoidance behavior, exhibition of "threat" behaviors such as aerial displays, "shielding" of young, abandonment of certain areas, and movement towards open waters (Gordon and Moscrop 1996; Hutchinson 1996; Janik and Thompson 1996; Kruse 1991; see Richardson et al. 1995 for review).

Air Traffic

While there has been little systematic study of the reactions of marine mammals and sea turtles to aircraft, there have been many reported opportunistic observations, particularly for pinnipeds. Generally, pinnipeds hauled out for pupping or molting are most responsive to aircraft (Born et al. 1999; Richardson et al. 1995). They react by becoming alert and often rushing into the water, which may result in the death of some smaller animals that are stampeded during the rush. Pinnipeds tend to react most strongly to aircraft that fly low, pass nearly overhead, and cause abrupt changes in sound (Richardson et al. 1995). For example, harbor seals will often temporarily leave haul-out areas when aircraft fly overhead, and do not always revisit to the same site when they return to land (Johnson 1977). Reactions of cetaceans to aircraft are not as well documented. Of the species that have been observed, the reactions usually consist of diving or turning abruptly, slapping the water with the flukes or flippers, changing course, rolling onto their side, or moving out of the area (see Richardson et al. 1995 for review). In Hawaii, low flying commuter traffic and small private planes are major sources of potential aerial disturbances as they cross areas of high whale concentrations (NMFS 1991a). As with boat traffic, low flying air traffic may cause airborne or waterborne acoustic disturbances that disrupt feeding, resting, socializing, migrating, or breeding behaviors of marine mammals and sea turtles.

In Maryland there is one international airport (Baltimore Washington International) and twenty-six smaller municipal airports scattered throughout the state, including one in Ocean City. There are also several military bases located in Maryland that have airfields. Flights leaving these airports may travel over the Chesapeake Bay and along the coast as part of their flight patterns, but the effect of this air traffic on marine mammals and sea turtles is unknown. Although the cruising altitude of most commercial flights is probably too high to cause acoustic disturbances that alter an animal's behavior, smaller commuter or private planes flying at lower altitudes may have a greater impact. Small planes used for distribution and abundance surveys of marine mammals and sea turtles along the Atlantic coast may fly as low as 500 feet. It is possible that these flights may disrupt or disturb marine mammal and sea turtle behavior, but this has yet to be systematically studied in Maryland.

Military Activity

Military activities such as sonar, hovercraft maneuvers, and target bombing are sources of acoustic and habitat disturbances that could adversely affect or injure animals in the area. Activities occurring along the coast may result in beach disturbance, which could disrupt sea turtle nesting activities and pinniped haul-out areas, resulting in injury or death. The military uses a range of active sonar, although the details of this equipment are classified and source levels are therefore not widely known (Gordon and Moscrop 1996). Evidence suggests that marine mammals exposed to low frequency sonar signals become silent, interrupt their activities, exhibit avoidance behaviors, alter swimming patterns, and may experience physical damage to the ears (Gordon and Moscrop 1996; Maybaum 1990, 1993; Richardson et al. 1995; Watkins et al. 1985, 1993; Watkins and Schevill 1975). Watkins et al. (1985) reported that sperm whales became silent, broke off their activities, and scattered in response to intense military sonar signals and Maybaum (1990) found that humpback whales in Hawaii responded to sonar pulses by moving out of the area. In March 2000 seventeen cetaceans (representing four species) stranded in the northern Bahamas in a single event. Gross examinations and head scans of five beaked whales that died revealed evidence of trauma to tissue associated with hearing, sound production, and airways. In particular all of the animals had hemorrhages in or around the ears (MMPA Bulletin 2000b). These injuries are consistent with an intense acoustic or pressure event. This unusual stranding event coincided with an U.S. Navv antisubmarine exercise in which several ships using standard, hull-mounted tactical sonar transited the area. It is possible that the animals suffered disorientation from a pressure or acoustic event related to the military activity and subsequently stranded. A joint investigation by the NMFS and the United States Navy is focusing on the tactical sonar as a possible cause of the stranding (MMPA Bulletin 2000a). There is little information available about reactions of marine mammals and sea turtles to military hovercraft, which can be used over water, ice, or land. Limited studies indicate that marine mammals may decrease spacing between individuals, change direction, stop traveling, dive abruptly, or leave an area in response to hovercraft (see Richardson et al. 1995 for review). Underwater explosions are common during military operations and may result in short-term avoidance reactions, or cause injury and even death.

As mentioned earlier, bases representing all branches of the military are located throughout Maryland. However, data regarding activities such as sonar use, target bombing, and hovercraft maneuvers are generally lacking. Therefore, to a large extent the impacts of military activity on marine mammal and sea turtle populations in Maryland are unknown. Typically, the military must submit notification of proposed activities or testing in Maryland waters to the various resource agencies, including the DNR, USFWS, NMFS, and MDE, for review and comment. Depending on the scope of the project and the comments of the resource agencies, the military develops an environmental assessment or impact statement to address concerns about potential impacts on humans and marine life in the area (R. Limpert, MDDNR, personal communication). The result of these assessments may indicate the need for strategies to minimize the effects of testing on the environment. These could include seasonal and area restrictions or minimum distance requirements for activities such as target bombing. Such measures may be effective in protecting populations of marine mammals and sea turtles in waters where proposed military activities are to take place.

Shoreline Development

Between 1970 and 1997, the population of the Chesapeake Bay region grew 28% to 15.1 million people, and will continue to grow at a rate of 300 new people each day (CBP 1999). This enormous population growth has lead to dramatic changes in the Bay's watershed and has become one of the top threats to the Bay's recovery. In addition, the population in Maryland has grown from approximately 3.6 million in 1960 to almost 5.2 million in 1994. Much of this growth has occurred along Maryland's Atlantic coast and has resulted in increased development and modifications of the natural shoreline, particularly in Ocean City. Coastal development, stabilization, and restoration can alter or degrade habitats such that they are unavailable and unsuitable for nesting or foraging sea turtles. Nesting habitat is threatened by a variety of factors, including beach armoring, increased vehicular and pedestrian traffic, beach nourishment, artificial lighting, beach cleaning, increased recreational use, and recreational beach equipment (Eckert 1995; Lutcavage et al. 1997; NRC 1990; NMFS 1991a, 1992, 1995, 1999). These factors may prevent females from accessing suitable nesting habitat, result in permanent loss of nesting habitat due to accelerated erosion, reduce nesting success, disorient hatchlings (resulting in fatality), cause females to abort nesting attempts, and increase the risk of mortality for females, hatchlings, and eggs (see NRC 1990 and Lutcavage et al. 1997 for reviews).

Coastal armoring includes structures such as sea walls, rock revetments, and sandbags that are installed in an attempt to protect beachfront property from erosion. These structures often block female turtles from reaching suitable nesting habitat and accelerate erosion further down the beach. Armoring is especially problematic along the east coast of Florida, where beach development is occurring in the very places where thousands of sea turtles come to nest.

Beach replenishment consists of pumping, trucking or otherwise depositing sand on a beach to replace what has been lost to erosion. While beach nourishment is often preferable to armoring, it can negatively impact sea turtles if the sand is too compacted for nesting or if the imported sand is drastically different from the native beach sediments, thereby potentially affecting nest-site selection, digging behavior, incubation temperature, and moisture content of the sand. In addition, if renourishment activities occur during the nesting season, nests can be buried far beneath the surface or run over by heavy machinery. In Maryland, beach replenishment has occurred in Ocean City and along Assateague Island as the result of erosion due to development and urbanization of the barrier islands. Since 1988, approximately 7.3 million cubic meters of offshore sand have been dredged and placed on Ocean City beaches to stabilize the island and protect beachfront property from storm damage (Maryland Geological Survey 2000). The Ocean City Inlet, located between Ocean City and Assateague Island, was formed during a hurricane in 1933. The following year the U.S. Army Corps of Engineers constructed jetties to stabilize the inlet for navigational purposes. The jetties interrupted the natural flow of sand to northern Assateague Island by trapping sand in the shoals around the inlet. As a result, the island has been rapidly eroding westward and losing volume. For example, a 1.5-mile stretch of the island dropped five feet after a northeaster hit the mid-Atlantic coast in February 1998 (Martin 1998). Restoration plans for Assateague Island include dredging 1.4 million cubic meters to widen the beach, constructing a low storm berm, and stabilizing the island (U.S. Army Corps of Engineers 2000). Periodic replenishment of sand to both Ocean City and Assateague Island will be necessary to prevent further breaching of the barrier islands.

Although sea turtle nesting in Maryland is rare, the occurrence of two loggerhead nests along the coast in 1999 suggests that loggerheads may be expanding their range to utilize Maryland's beaches. One of the nests was located on a public beach at 62nd street in Ocean City, an area subject to high pedestrian traffic, strong artificial lights, and sea wall barriers. As a result, the nest was relocated to the north end of Assateague Island, where human impacts were minimal. If nesting continues on Maryland's beaches, factors related to beach replenishment could negatively impact females and the hatching success of their nests. In addition, the use of hopper dredges to harvest offshore sand for beach restoration projects may also be a source of potential harm for sea turtles in Maryland waters.

Dredging

Dredging of inshore and nearshore areas, particularly harbors and entrance channels, and the disposal of dredged material adversely affects sea turtles through incidental take and destruction or degradation of habitat. Hopper dredges are responsible for the incidental take and mortality of sea turtles along the southeastern and mid-Atlantic coasts of the United States (Lutcavage 1997; USFWS & NMFS 1992). Within a three month period in 1980, hopper dredging was responsible for the mortality of 77 loggerheads during the removal of 2.5 million cubic yards of sediment from the Port Canaveral Channel, Florida (NRC 1990). Maintenance dredging of the King's Bay, Georgia, during 1987 and 1988 resulted in the mortality of at least 18 sea turtles. In addition to direct takes, channelization of habitats and disposal of dredged material can destroy and disrupt resting and foraging grounds (including SAVs) through degraded water quality and altered current flow (NMFS & USFWS 1991; USFWS & NMFS 1992).

Nationwide, about 400 million cubic yards of sediment are dredged from shipping channels each year (Blankenship 1996). In the Chesapeake Bay, about 5.3 million cubic yards of sediments must be dredged every year to maintain the channels serving the Port of Baltimore from the north (Chesapeake and Delaware Canal) and south (Cape Henry) (Blankenship 1996; Williams 1999). Most of the dredged material is either placed in an open water site or at Hart-Miller Island, a large containment site in the upper Chesapeake Bay that is projected to be full by 2009 (Blankenship 1996). Finding ways to dispose of the dredge spoil is increasingly difficult and has been a major source of debate in the region. In recent years there has been much discussion regarding the utilization of dredged material for beneficial use projects, specifically to create and rebuild disappearing wildlife habitat within the Chesapeake Bay. For example, material dredged from a nearby channel was pumped to the rapidly eroding west shore of Barren Island, located in the middle Chesapeake Bay, to replace disappearing habitats for a wide variety of species such as terns, diamondback terrapins, fish, and shellfish. However, there are environmental concerns about the potential impact of dredged material on bottom habitats, which are critical for shellfish and benthic organisms, spawning areas, and open water habitats for fish and other marine species including sea turtles (Blankenship 1994, 1996; Williams 1999).

There are several federal projects along the Maryland coast that utilize hopper dredges to harvest offshore sand for restoration projects or to deepen navigational channels. Section 7 of the ESA requires the U.S. Army Corps of Engineers (ACOE) to consult with the NMFS or USFWS on all actions that may affect threatened or endangered species. As part of the consultation process, the ACOE prepares Biological Assessments to evaluate the potential effects of the proposed dredging projects along Maryland's Atlantic Coast on marine mammals and sea turtles and their habitats. Specific concerns include the entrainment of sea turtles by hopper dredge dragheads and vessel collisions with whales. Based on reviews of these Biological Assessments and available commercial and scientific information, the NMFS concluded that several dredging projects, including a long term (25 years) sand management project on Assateague Island, an Assateague State Park Beach Nourishment Project (involving the Maryland DNR), and an Atlantic Coast Shoreline Protection Project, may adversely affect, but were not likely to jeopardize the continued existence of several species of sea turtles (J. Nichols, NMFS, personal communication). The projects were also not likely to affect marine mammals, specifically whales, in the proposed dredging areas. The NMFS authorized an incidental take allowance of sea turtles for each project and in most cases required the ACOE to conduct monitoring of hopper dredge operations by trained NMFS observers during at least 25 percent of the dredging cycle for each of the projects. The NMFS Biological Opinion issued for each of the proposed projects also included a list of reasonable and prudent measures to minimize impacts of incidental take to sea turtles. These measures include the use of deflectors on the draghead to reduce the risk of interaction with sea turtles present in the dredging area. The Section 7 consultation process ensures that the effects of dredging on listed marine mammals and sea turtles along Maryland's Atlantic coast are minimized, which is an important measure in the recovery and conservation of these threatened and endangered species.

Power Plant Intake

Approximately 98 power-generating facilities along the Atlantic coast of the United States and the Gulf of Mexico use ocean or estuarine water for their cooling systems (NRC 1990). The entrainment and entrapment of sea turtles in cooling intake systems of coastal power plants has been documented in New Jersey, Maryland, North Carolina, Florida, and Texas (NMFS & USFWS 1991; NRC 1990). Average annual incidental capture rates for most coastal plants for which captures have been reported are several turtles per plant per year. The best-documented case of sea turtle mortality in cooling intake systems is the St. Lucie nuclear power plant in southeastern Florida. From 1976 to 1999, 2,193 sea turtles were removed from the intake canal, with a mortality rate of about 7 percent or an average of 11 turtles per year (NRC 1990). There are sixteen power plants in Maryland; fourteen are located on the Chesapeake Bay or one of its tributaries and draw most of their cooling water from these sources. Over the last two decades several studies have been conducted to evaluate the impacts of 12 major power plants on the aquatic environment, with emphasis on the Chesapeake Bay. The results of these studies indicated that the power plants, taken together, had no identifiable substantive cumulative impact on Maryland's aquatic resources, particularly fish, crabs, plankton, and larvae (MDDNR 1998). However, quantitative studies of the impact of these plants on sea turtle mortality appear to be lacking. The existing data suggest that mortality of sea turtles in power plant cooling systems is low in Maryland; perhaps only two or three turtles in the last twenty-five years. In June 1997 Maryland stranding network personnel responded to a loggerhead sea turtle found dead in the intake of the Calvert Cliffs Nuclear Power Plant, located in Calvert County on the Chesapeake Bay.

Harassment

Harassment of marine mammals and sea turtles has increased as the popularity of recreational boats, whale-watching vessels, and swim-with-the-dolphin programs has grown. The rapid growth of these industries has raised concerns about their impact on wild populations of marine mammals and sea turtles. Personal watercraft (jet skis), which are fast and easy to maneuver, are involved in a disproportionate share of boating accidents (27.9% in Maryland in 1998) and pose a hazard to the environment (Bay Journal 1999; Witt 2000). They create noise pollution that disturbs a variety of marine life, including marine mammals and nesting birds, and water pollution by discharging fuel and oil into the water (Bay Journal 1999). In Maryland, the number of personal watercraft more than tripled in the 1990s. In 1998, 14,385 personal watercraft were registered or documented in the state (Witt 2000). Their noise, high speeds, and erratic motions are likely to disturb marine mammals and sea turtles that utilize the Chesapeake Bay and coast. To help combat this growing problem, the National Park Service announced in March 2000 that it would regulate use of personal watercraft in 87 Federal parks, recreation areas, seashores, and other properties under its jurisdiction. The agency outlawed personal watercraft in some of its parks while permitting their use in others. The park superintendent of AINS is banning personal watercraft from most waters around the island. The restrictions are intended to reduce noise and water pollution and provide a more pristine environment for the island's inhabitants and visitors (Witt 2000). The hope is that these restrictions will also help to reduce reported incidences of marine mammal harassment.

Commercial whale watching began in the United States in the 1950s and has grown tremendously in recent years (Lavigne et al. 1999). About 66% of all whale watching worldwide occurs in the United States. The rapid growth of this industry, often in the absence of regulations, has raised concerns about it impacts on wild populations of marine mammals. Large-scale, unregulated whale watching involving boats circling and pursuing animals will temporarily disrupt behaviors such as breeding, nursing and feeding (Clapham et al. 1999; Richardson et al. 1995; Slooten and Dawson 1995). For example, a study of the responses of sperm whales to whale-watching vessels in New Zealand indicated changes in behavior, including diving without fluking, significantly shorter surface times, and shorter blow intervals (Gordon et al. 1992). The waters off British Columbia support a large number of free-ranging killer whales, as well as a growing commercial whale-watching industry. In the early 1980s it was common to see a group of whales being followed by as many as four whale-watching boats. Kruse (1991) reported that the killer

whales showed a clear response to the presence of boats by swimming faster (the more boats present the faster they swam) and moving towards open water. While the long term effects of harassment have not been studied, the continual or chronic interruption of activities such as feeding, resting and reproduction may have a significant impact on a population's biological fitness.

The popularity of ecotourism has led to a growing problem of the public interacting with marine mammals in the wild. Feeding wild dolphins has been an ongoing problem since the late 1980s, especially in many southeastern coastal states, including Florida, Texas, and the Carolinas (NOAA 1997). Feeding marine mammals in the wild alters their natural behavior such that they are at increased risk of injury or death. Repeated exposure to human activities may result in interactions with fisheries (e.g., entanglement, drowning) and ingestion of inappropriate and contaminated food items, which can result in death. In addition, feeding may impact an animal's ability or willingness to forage for food, which is of particular concern for young animals that must learn foraging skills in order to survive (NOAA 1998, 1999b). Captive and wild dolphin swim and feeding programs ("Swim-with-the-dolphins"), which occur in many places in Florida and the southeastern United States, are also a concern because they have the potential to disturb behavioral patterns. In addition, swimming with wild dolphins is closely linked to people feeding them, which is dangerous for both participants. People who feed or swim with dolphins are at risk of being injured, particularly by being bitten or pulled under the water by animals begging for food. Observations suggest that dolphins that consistently participate in such behaviors can become aggressive when they are not rewarded with food.

Feeding or harassing marine mammals is illegal under the MMPA of 1972 and violators are subject to civil and criminal penalties ranging from \$10,000 to \$20,000 and one year in prison. In July 1998, NOAA charged a Panama City boat rental company and its boat operator with five civil violations of feeding or attempting to feed wild dolphins. A Federal Administrative Law Judge upheld the charges and requested sanctions of \$4,500 and ordered the rental boat company to post a "no dolphin feeding" sign on the grounds of the facility (NMFS 1998b). There have been several unverified reports of tour boat companies harassing marine mammals along the Maryland coast. In 1999, a family was observed feeding a wild dolphin from their boat in the Isle of Wight Bay. Although whale and dolphin watching is not a major industry in Maryland waters, it is still an issue that should be addressed through the development of whale watching guidelines and educational curriculum.

Natural Causes

In addition to anthropogenic factors, there are a variety of natural causes of marine mammal and sea turtle mortality, including age, predation, disease, parasites, environmental conditions, low reproductive rates, and reduced prey availability.

Age

As is typical in many large mammals, mortality in marine mammals is usually highest in the youngest and oldest age classes (Geraci et al. 1999). For example, more than fifty percent of pinnipeds born in certain populations may not survive their first year as a result of factors including trauma, disease, starvation, and severe weather (Berta and Sumich 1999). Generally, sea turtle eggs and hatchlings have the highest mortality rates, but as the survivors grow, natural mortality declines noticeably and then rises again with older adults. Annual survivorship in loggerheads is lowest in eggs and hatchlings (67% per year) and in large juveniles and subadults (68%) (NRC 1990).

Predation

Natural predation is also a factor affecting marine mammal and sea turtle populations. Young and compromised (i.e., injured or sick) animals are at highest risk for predation by a variety of carnivores. Most obvious is predation of sea turtle nests by small and medium-sized mammals (e.g., mongooses, coyotes, raccoons) and crabs, particularly ghost crabs (NRC 1990; Stancyk 1995). In the southeastern

United States, raccoons can take up to 96 percent of the loggerhead nests on some beaches (Stancyk 1995). Hatchlings are preyed upon by land-based predators, including mammals, crabs, and birds (e.g., vultures, frigate birds, gulls), as well as aquatic predators, including gulls, terns, sharks, snook, barracuda, and other predatory fish (NRC 1990). Although the numbers and diversity of potential predators decrease as marine turtles grow, there are still some predators capable of engulfing hard-bodied prey. Sharks, particularly the tiger shark, are the most commonly observed predators of juvenile and adult sea turtles. Young or sick marine mammals can be preyed upon by a variety of terrestrial and aquatic carnivores, including wolves, coyotes, foxes, eagles, sharks, polar bears, killer whales, and leopard seals (Berta and Sumich 1999; Geraci et al. 1999). For some species, such as the crabeater seal, predation may be the greatest single cause of mortality in young animals.

Environmental Conditions

Unusual environmental conditions or changes can result in marine mammal and sea turtle mortality. As discussed earlier, certain algae and protozoa, particularly dinoflagellates, produce toxins that can accumulate in fish and invertebrates and eventually poison predators higher up the food chain, including marine mammals and sea turtles. Harmful algal blooms (HABs) have been implicated in a number of mortalities; in 1946 and 1947 red tides off western Florida killed invertebrates, turtles, and fish and were circumstantially linked to the deaths of several bottlenose dolphins (Geraci et al. 1999); in 1978 more than 25% of the Hawaiian monk seal population on Laysan Island was apparently poisoned after consuming fish containing ciguatoxin and subsequently died from starvation and infection (Geraci et al. 1999); and in 1998, a toxic diatom bloom was linked to the poisoning of more than 70 California sea lions along the central California coast, many of which suffered from neurological dysfunction and died (Scholin et al. 2000).

Many species of marine mammals and sea turtles are vulnerable to extreme weather. Prolonged or intense cold spells in the southeastern United States periodically kill large numbers of Florida manatees and cause hypothermia or cold stunning of sea turtles, which can lead to death (Geraci et al. 1999; NRC 1990). Inshore populations of turtles are particularly susceptible to cold stunning because the water temperature can change rapidly in shallow waters. Between November 1999 and January 2000, more than 277 cold-stunned sea turtles, including loggerheads, Kemp's ridleys, and greens, stranded in Massachusetts. This unusually large stranding event occurred because turtles swept north with the warm Gulf Stream became trapped when the water quickly turned cold in the early winter. Ice accidents are a common hazard for cold-water species. Beluga whales and narwhals can become trapped in ice by an early fall or late spring freeze and may starve or be taken by natural predators or human hunters. Along the southern coast of Newfoundland, blue whales and schools of white-beaked dolphins are sometimes forced ashore by wind-driven ice (Geraci et al. 1999).

Other environmental changes, such as those associated with El Niño southern oscillation events, can dramatically alter the availability of particular prey species. During an El Niño event, regular oceanic and atmospheric patterns dramatically change and many physical and biological systems are disrupted. Trade winds relax, sea level and sea-surface temperatures rise, and the thermocline depth increases. During such an event there is a large-scale movement of food organisms to colder waters. This usually means that fish are either found deeper or have migrated out of range. Thus, the overall productivity of the marine environment generally decreases due to the decline in fish and plankton abundance. As a result, the distribution, abundance, and quality of prey for some marine mammals decrease, which can lead to widespread starvation and death (Geraci et al. 1999).

Diseases

In the past few decades, there has been a world-wide increase in reports of diseases affecting marine organisms (Harvell et al. 1999). However, the dynamics of disease outbreaks, as well as their ecological and evolutionary impacts on marine ecosystems, are poorly understood. In the North Atlantic, the frequency of marine mammal mass strandings appears to be increasing, particularly in heavily polluted

coastal areas. Mass mortalities have occasionally been attributed to bacteria, such as *Pneumococcus* sp., which killed up to 50 percent of gray seal pups in Scotland in 1960, and leptospirosis, which is endemic in California sea lions and has killed several hundred animals since the 1970s (Geraci et al. 1999). While bacteria have been identified in only a few large-scale die-offs, viruses have been implicated in nearly all of the mass mortalities attributed to infectious disease in the last twenty years. Viruses known or suspected to infect marine mammals include those causing Influenza A, papillomas, genital warts, and plaques on penile or vaginal epithelia, which could interfere with successful reproduction (Berta and Sumich 1999; Geraci et al. 1999). Influenza A killed an estimated 450 harbor seals (3-5% of the population) along the New England coast in 1979-1980.

Of greater concern are the morbilliviruses, which are potentially lethal and widespread among marine mammals. The virus suppresses immune system responses, leaving an animal vulnerable to secondary bacterial infections (Berta and Sumich 1999). In 1987-1988, an outbreak of canine distemper, which was possibly transmitted through direct or indirect contact with sled dogs, killed thousands of Baikal seals in Siberia (Harvell et al. 1999; Kennedy 1998). This episode was followed by morbillivirus outbreaks that swept through populations of harbor and grey seals in the coastal waters of northwestern Europe in 1988, striped dolphins in the Mediterranean in 1990 through 1992, harbor porpoises in northwest Europe in 1988 through 1990, and bottlenose dolphins along the eastern coast of the United States in 1987-1988 and in the Gulf of Mexico in 1993-1994 (Geraci et al.1999; Kennedy 1996, 1998; Lipscomb et al. 1996). Morbillivirus infection, without associated mortality, is now known to be common in many species of marine mammals, including long-finned pilot whales, manatees, harp seals, hooded seals, white-beaked dolphins, monk seals, crabeater seals, fin whales and minke whales (Kennedy 1998).

Sea turtles are subject to a variety of bacterial, fungal, and viral diseases (see George 1997 for review). Bacterial infections are rare in wild sea turtles, as a result of their tough integument and competent immune system, which minimize opportunities for bacteria to enter the body. Trauma to tissues and aspiration of seawater are the primary routes by which bacteria come into the body. This can lead to abscesses, pneumonia and eventually lethal septicemia as the bacteria enters the bloodstream (George 1997). Bacterial encephalitis, caused by Corynebacterium sp., has been documented in stranded juvenile loggerhead sea turtles in the Chesapeake Bay and along the coast of Florida. Fungal infections are not common in sea turtles and wild turtles are less vulnerable to fungal pathogen exposure due to their solitary habits. A major epizootic disease affecting a variety of species of sea turtles is cutaneous fibropapillomatosis. While it occurs primarily in green turtles, is has also been documented in loggerhead, olive ridley, hawksbill and flatback turtles (George 1997). Affected turtles exhibit large external tumors that may impair movement or grow over the mouth or eyes inhibiting feeding, breathing or vision, thus compromising the animal and leading to mortality (Hutchinson and Simmonds 1992; NRC 1990). The etiology of fibropapillomatosis has yet to be confirmed, but it is thought to be a viral disease. Other possible causes of the disease include a variety of environmental stress factors, bacterial infections, chemical contaminants, ectoparasites, and other viral infections (George 1997).

Marine mammals harbor a wide range of parasites, which typically have little effect on the host unless the animal is also stressed by illness, injury, or starvation. When this situation arises, usually harmless parasites, such as nematodes in the lungs or stomach, can become pathogenic (Geraci et al. 1999). For example, nematodes of the genus *Crassicauda* are serious pathogens of cetaceans. They destroy mammary gland tissue and can cause potentially lethal cranial bone lesions in odontocetes and renal failure in rorquals. In North Atlantic fin whales (and other rorquals), *Crassicauda* causes infection of the urogenital tract, which sometimes leads to renal failure. The resulting calf mortality may be high enough to hinder species recovery (Geraci et al. 1999). A variety of parasitic infections, both external and internal, have been documented in sea turtles. Some parasites occur in large numbers, causing extensive damage that eventually debilitates the animal. Ectoparasites found in sea turtles include

leeches, which in large numbers can cause anemia and act as vectors for various disease-producing organisms. Barnacles contribute to the overall stress of the animal by increasing surface drag and damaging the shell and skin, providing a pathway for bacterial or fungal pathogens to enter the body (George 1997). Endoparasites include protozoans and helminths, particularly trematodes and nematodes. Spirorchid trematodes (blood flukes) are the most damaging parasites to sea turtles. Blood flukes may serve as the disease vector for spirorchidiasis, a chronic debilitating disease that results in emaciation, anemia, and enteritis. Spirorchidiasis can eventually result in death or cause a turtle to become more susceptible to other diseases (George 1997; NRC 1990).

Poor recruitment

For some species of marine mammals, factors such as late age at sexual maturation and inherently low reproductive rates can adversely affect the population. The age at which an animal reaches sexual maturity can be in the mid to late teens for some species, such as the sperm whale (20 years for males; Perry et al. 1999) and the bowhead whale (15-20 years; Clapham et al. 1999). Unfortunately, many of these animals will not survive to reach sexual maturity as the result of anthropogenic factors such as ship strikes, fisheries entanglement, or subsistence hunting. The effect of this mortality is a reduction in the reproductive success of the species, which can have a significant impact on the recovery of a depleted or endangered population. In addition, many species of marine mammals, including the northern right whale, manatee, sperm whale, fin whale, and sei whale have calving intervals that range from two to five years, as compared to other marine mammals that reproduce every year or two. This inherently slow rate of reproduction may make it difficult for a population, which is already depleted, to recover over time. For example, reproductively active northern right whale females appear to rear calves successfully about once every 3 to 5 years. Given this inherently slow rate of recruitment and the small size of the western North Atlantic population (less than 350 individuals), it may take 150 years or more for the population to recover to levels that would permit the changing of their status from endangered to threatened (NMFS 1991b). The vulnerability and recovery potential of a threatened or endangered species are in part contingent upon fundamental characteristics of the species' ecology and life history.

RECOVERY

The following is a comprehensive, non-prioritized list of recommended recovery actions deemed necessary to contribute to the recovery and sustainability of marine mammal and sea turtle populations utilizing Maryland waters. An implementation schedule prioritizing the recovery actions can be found in Table 1 at the end of the recovery narrative. The plan sets out six main objectives: 1) enhance marine mammal and sea turtle stranding network efforts; 2) enhance commercial fisheries and fisheries/marine mammal and sea turtle interaction data in Maryland waters; 3) improve and increase law enforcement and regulation efforts; 4) identify, document, and minimize impacts of commercial and recreational activities on sea turtles and marine mammals; 5) establish cooperative research efforts in Chesapeake Bay and along Maryland coastline; and 6) improve and promote education and public outreach efforts. Recommended legislative, enforcement, management, and research tasks are detailed below. The objectives emphasize the need to obtain data in many areas where current information on marine mammals and sea turtles are lacking, including life history, distribution, abundance, anthropogenic factors, and enforcement efforts. Most importantly, these recovery actions can only be accomplished through the development of partnerships between federal, state, and local agencies, organizations, and academic institutions within the state of Maryland.

RECOVERY OUTLINE

OBJECTIVE 1. Enhance marine mammal and sea turtle stranding network efforts.

- 1.1. Expand current Maryland marine mammal and sea turtle necropsy facility at Cooperative Oxford Laboratory (COL).
- 1.2. Develop volunteer program for COL stranding network.

- 1.3. Develop seal stranding protocol.
- 1.4. Develop sea turtle nesting protocol.
- 1.5. Maintain marine mammal and sea turtle database.
- 1.6. Analyze stranding data (1990-present) and publish results.

OBJECTIVE 2. Enhance commercial fisheries and fisheries/marine mammal and sea turtle interaction data in Maryland waters.

- 2.1. Identify and document known and potential impacts of fisheries activities.
 - 2.1.1 Identify and list critical fisheries data.
 - 2.1.2 Identify important fisheries to monitor.
 - 2.1.3. Document location and season of fisheries in Bay and along Atlantic coast and compare with stranding data.
 - 2.1.4. Establish or designate a fisheries data collection staff position.
- 2.2. Establish sea turtle tagging study through cooperative efforts with pound netters.
- 2.3. Implement coastal and Chesapeake Bay fisheries observer program to document interactions.

OBJECTIVE 3. Improve and increase law enforcement and regulation efforts.

- 3.1. Document and clarify existing legislation and regulations.
- 3.2. Document and clarify agencies' responsibilities.
- 3.3. Identify ways to promote coordination and response.
 - 3.3.1. Develop and implement a violation enforcement and reporting action plan/protocol.

OBJECTIVE 4. Identify, document, and minimize impacts of commercial and recreational activities on sea turtles and marine mammals.

- 4.1. Develop and implement methods to reduce incidental take in commercial fisheries.
 - 4.1.1. Implement seasonal restrictions for commercial fisheries operations with known impacts.
 - 4.1.2. Monitor and reduce mortality from dredging activities.
 - 4.1.3. Implement TED regulations for commercial trawlers with known impacts.
- 4.2. Identify, document and minimize impacts of recreational activities.
 - 4.2.1. Development of marine mammal and sea turtle viewing guidelines and permits.
 - 4.2.2. Enforce boating and jet ski regulation.
- 4.3. Develop and implement guidelines regarding marine mammal and sea turtle harassment and the possession of parts.
- 4.4. Identify, document and minimize impacts of military activities.

OBJECTIVE 5. Establish cooperative research efforts in Chesapeake Bay and along Maryland coastline.

- 5.1. Collect life history information on marine mammals and sea turtles.
 - 5.1.1 Determine and monitor the habitat utilization of marine mammals and sea turtles in Maryland waters.
 - 5.1.2. Determine and monitor feeding ecology, both spatially and temporally, of marine mammals and sea turtles in Maryland waters.
- 5.2. Determine and monitor age class structure of marine mammals and sea turtles in Maryland waters (including reproductive rates).
- 5.3. Determine the genetic stock structure of marine mammals and sea turtles in Maryland waters
- 5.4. Monitor abundance and distribution, both temporally and spatially, of marine mammals and sea turtles in Maryland.

- 5.5. Investigate health, disease, parasitism and contamination effects of marine mammals and sea turtles in Maryland.
- 5.6. Determine and monitor mortality rates of marine mammals and sea turtles in Maryland.

OBJECTIVE 6. Improve and promote education and public outreach efforts.

- 6.1. Identify ways to promote and improve information dissemination.
 - 6.1.1 Develop public service announcements regarding marine mammal and sea turtle issues.
 - 6.1.2. Post information signs for marine mammal and sea turtle issues at public access points.
 - 6.1.3. Develop and distribute new educational and outreach materials.
- 6.2. Incorporate a marine mammal and sea turtle educational curriculum into boater and PWC safety courses.
- 6.3. Provide training and educational workshops.
- 6.4. Develop marine mammal and sea turtle education curriculum for agencies, organizations, schools, and general public.
- 6.5. Identify ways to improve public participation.

RECOVERY NARRATIVE

OBJECTIVE 1. Enhance marine mammal and sea turtle stranding network efforts.

1.1. Expand current Maryland marine mammal and sea turtle necropsy facility at Cooperative Oxford Laboratory (COL).

Until recently, the stranding team at the COL conducted marine mammal and sea turtle necropsies in a lean-to, which consisted of a cement slab with walls on two sides and overhead lighting. This outdoor facility provided little in the way of protection from the elements and had a poor drainage system. Expansion of the current necropsy facility is well underway at the COL. A new laboratory is being constructed and is due to be completed and fully equipped by late 2001 or early 2002. The 450 square foot lab space will be outfitted with new equipment, including a stainless steel sink with drainboards, a refrigerator, and mobile necropsy table, freezers (including a –70), a chemical storage cabinet, countertops, waterproof electrical outlets, overhead lighting, air conditioning, rough plumbing for a toilet and shower, a slanted floor, a floor drain, and a garage door. This modern lab facility will be more convenient and productive for conducting marine mammal and sea turtle necropsies, storing samples and maintaining expensive equipment.

1.2. Develop volunteer program for COL stranding network.

The Marine Mammal and Sea Turtle Stranding Network located at the COL in Oxford, Maryland (on Maryland's eastern shore) depends primarily upon four full-time employees to respond to dead strandings in the Maryland Chesapeake Bay and along the coast-line. Travel time to a stranding site can take in excess of four hours when the stranding is located on the western shore of Maryland, across the Chesapeake Bay from the COL. This is a large area to cover with a restricted number of staff. The establishment of a small volunteer network around the Chesapeake Bay and along the coast would greatly benefit stranding personnel at the COL by providing additional support for stranding response (particularly on the western shore of Maryland). A small group of trained volunteers from the Patuxent Naval Air Station, Calvert Marine Museum, and Point Lookout State Park currently assist the Maryland stranding team with strandings in southern Maryland when needed. Training workshops conducted by COL staff would provide instruc-

tion on marine mammal and sea turtle species identification, proper necropsy, sample collection, and data recording techniques and the importance of information gleaned from strandings. Volunteers would be required to accompany stranding network personnel on several strandings during the training process to demonstrate the application of learned techniques. Upon completion of training, volunteers would be called upon to travel to a stranding site to verify species, assist with necropsies and data collection, and perform necropsies when needed.

1.3. Develop seal stranding protocol.

The mid-Atlantic region of the United States has experienced increased numbers of stranded pinnipeds in recent years. Prior to that time, seal strandings were rare in Delaware, Maryland, Virginia, and North Carolina, and a stranding response protocol was not in place. With the increase in seal strandings in these states, a seal stranding response protocol is needed to coordinate the efforts of stranding teams in the mid-Atlantic region. An informal meeting consisting of stranding team members from each mid-Atlantic state was held at the Virginia Marine Science Museum in 1996 to discuss the stranding response protocol. Specifically, areas in need of improvement were identified and topics to be covered in the document were addressed. After the meeting, a document was drafted that includes information on species identification, guidelines for deciding whether to collect a stranded seal, a list of essential diagnostics and treatments, available and potential rehabilitation facilities, public education and awareness materials and media relations information. The draft document needs to be completed, reviewed for content by related parties, and circulated to the mid-Atlantic states to ensure a coordinated and consistent effort in pinniped stranding response.

1.4. Develop sea turtle nesting protocol.

Sea turtle nesting north of Virginia is extremely rare. The first documented loggerhead sea turtle nest in Maryland occurred in Ocean City in July of 1972. No other nests were documented until the summer of 1999, when two loggerhead sea turtle nests were reported along the coast of Maryland. Although both nests were relocated above the high tide line on the north end of AINS, protected with exclosures, and monitored throughout the remainder of the summer, neither nest was viable. The rarity of nesting events in Maryland prior to 1999 has prevented the need for the development of a sea turtle nesting protocol. As a result of the 1999 nests and in anticipation of future nesting events, a standard operating procedure for sea turtle nesting should be prepared. The development of a nesting protocol should be a cooperative effort between AINS, NMFS, MDDNR, USFWS, and Ocean City Public Works. This protocol should address issues such as species identification, monitoring, marking, protecting, and relocating nests along Maryland's coast. It should also include educational information to raise public awareness of sea turtle nesting and the effects of human activities such as beach development, pedestrian traffic, and artificial lighting on sea turtles and their nests.

1.5. Maintain marine mammal and sea turtle database.

Personnel at the COL enter data collected from dead strandings in Maryland into a Visual D-base program. The maintenance of this database is vital to the stranding program, as it allows for quick searches of information regarding species, sex, length, evidence of human interaction, location, etc., of a stranded animal, which can be important for determining and monitoring trends in Maryland waters. Currently, stranding data is being

transferred into a Microsoft Access database, which will be more convenient and accessible to stranding personnel for entering, maintaining, and searching stranding data.

1.6. Analyze stranding data (1990 to present) and publish results.

Data collected by stranding network personnel at COL should be periodically compiled and analyzed to determine trends in the stranding data. The data should also be summarized in a review of stranding network efforts and submitted to a relevant journal for publishing. One such article, which discussed sea turtle strandings in Maryland from 1991 to 1995, was published in the Maryland Naturalist in 1997 (Evans et al. 1997). A more recent review of strandings (1995-2000) should be compiled and submitted for publication. In addition, case reports involving new or unusual findings should be drafted and submitted for publication in a timely manner.

OBJECTIVE 2. Enhance commercial fisheries and fisheries/marine mammal and sea turtle interaction data in Maryland waters.

2.1. Identify and document known and potential impacts of fisheries activities.

The effects of fisheries on marine mammal and sea turtle populations in Maryland waters are largely unknown. The existing data consists of bycatch reported by commercial fishermen and fisheries interactions documented from strandings. However, this data is insufficient to calculate estimations of mortality due to commercial fishing activities. Therefore, more quantitative fisheries information should be collected to determine the impact of the industry on marine mammal and sea turtle populations.

2.1.1. Identify and list critical fisheries data.

The first step in documenting the impact of fisheries on marine mammals and sea turtles in Maryland is to identify critical fisheries data needed to make such a determination. Information such as seasonality, location, fishing effort, landings, gear type, mesh size, target species, and bycatch for a particular commercial fishery is necessary to establish which fisheries may be having an impact on marine mammal and sea turtle populations. At the state level (fisheries < 3 mile limit) most of this data is collected and archived in an Microsoft Access database maintained by the Maryland DNR. Federal fisheries statistics (>3 miles) are collected and summarized by the NMFS. Both sets of data should be made readily available to aid in this determination.

2.1.2. Identify important fisheries to monitor.

Preliminary data collected by the state suggests that some fisheries, such as trawls and gill nets, are incidentally taking marine mammal and sea turtles. However, mortality due to these activities has yet to be quantified. These fisheries should be targeted and monitored to provide better estimations of mortality over time.

Specifically, more information is needed on:

- 1) The Chesapeake Bay pound net fishery and its affects on sea turtles.
- 2) The Atlantic croaker ocean gillnet fishery and its affect on sea turtles and marine mammals.

- 3) The striped bass ocean gill net fishery and its affect on marine mammals from late fall through early spring.
- 4) The ocean trawl fishery and its affect on sea turtles from late spring through early fall.
- 2.1.3. Document location and season of fisheries in Bay and along Atlantic coast and compare with stranding data.

Some preliminary evidence and observations suggest that sea turtle and marine mammal mortalities may coincide temporally and spatially with certain fisheries. To further investigate this possibility, a correlation should be made between commercial fisheries and strandings. Particular attention should be paid to the timing and location of fisheries where marine mammal and sea turtle mortality is known to occur. The concurrent distribution of commercial fisheries and marine mammal and sea turtle strandings should be documented. Maps plotting the precise location of strandings (based on latitude and longitude) and the area of operation of a particular fishery can be generated to aid in this determination. A reexamination of stranding records may indicate that the documentation of a probable fisheries interaction on a stranded animal is consistent with a fishery operating in the area at the same time. For example, measurements of the space between linear impressions on the body of a dead stranded marine mammal may match the mesh size of a gill net fishery operating in the area. Or perhaps a spike in the number of sea turtle strandings in a particular area coincides with hopper dredging activities during the same time frame. Although these comparisons may not provide a definitive confirmation of a fisheries interaction, they will give an indication of which fisheries could potentially interact, both spatially and temporally, with marine mammals and sea turtles. Once identified, these fisheries can be targeted and monitored to assess the level of mortality. This data is necessary to determine if regulations and restrictions should be developed to reduce incidental take in a particular commercial fishery.

2.1.4. Establish or designate a fisheries data collection staff position.

The collection of the appropriate fisheries data (as described above) is critical in determining the effect of commercial fisheries on marine mammals and sea turtles in Maryland. To ensure that all of the necessary data is systematically collected the Maryland DNR should hire or designate a fisheries biologist for this specific purpose. The role of this individual will be to work with key staff from DNR and other affected agencies to: 1) identify critical fisheries data (as described above); 2) review historical data that document interactions between fisheries and marine mammals and sea turtles; 3) correlate fisheries and marine mammal and sea turtle strandings; 4) based on the results of 2) and 3), identify fisheries that need to be monitored to assess mortality over time; and 5) develop a protocol outlining the methods that will be used to acquire the data (surveys, fisheries observers, bycatch forms, etc.). Designating an individual to complete these actions will ensure that the necessary data are systematically collected and maintained.

2.2. Establish sea turtle tagging study through cooperative efforts with pound netters.

Data on the effects of the Maryland Chesapeake Bay pound net fishery on sea turtles is lacking (see 2.1.2). In addition, with the exception of data collected by the Maryland Marine Mammal and Sea Turtle Stranding Network, little is known about sea turtle biology and ecology in Maryland's Chesapeake Bay. In September 2000, COL received Section 6 funding for a sea turtle pound net tagging and health assessment study in Maryland's Chesapeake Bay to begin in 2001. This project is similar to the pound net tagging study conducted by the Virginia Institute of Marine Science over the last twenty years. The incidental capture of sea turtles in pound nets provides a unique opportunity to study these animals, which would other be inaccessible in Maryland waters. Through the development of a cooperative agreement with pound net fishermen in Maryland, sea turtles incidentally captured in pound nets are weighed, measured, sampled for tissue and blood, tagged (flipper and PIT) and released. Over time, the collection of this data will provide vital information on habitat utilization, migratory behavior, age, growth, baseline health, sex, and geographical origin of sea turtles in the Chesapeake Bay.

The sea turtle tagging and health assessment study will also provide an opportunity to characterize the pound net fishery in the Chesapeake Bay. A solicitation mailing was sent to all active pound net fishermen in Maryland in June 2001 with some general questions about incidental captures of sea turtles and their willingness to participate in the study. Information such as mesh size, the use of stringer meshing in the leaders, location of the pound net, target species, current, water depth, and water temperature will be collected from the site of each incidental capture when possible. This information is extremely important to determine the effects of the pound net fishery on sea turtle entanglement and mortality in Maryland's Chesapeake Bay.

2.3. Implement a coastal and Chesapeake Bay fisheries observer program to document interactions.

The NMFS deploys fisheries observers on commercial fishing and processing vessels in 18 different fisheries throughout United States waters to collect catch and bycatch data for scientific, management, compliance, and economic purposes. The fishery observer program is considered to be the best source of information on the status of many fisheries and on bycatch of protected species, such as marine mammals, sea turtles, and sea birds (NMFS 2000). Observers are deployed in gill net fisheries in the mid-Atlantic region and in dredge, trawl, and pelagic longline fisheries in the Atlantic Ocean. As described in the anthropogenic factors section of this document, data collected by NMFS observers indicate the incidental capture of several species of marine mammals and sea turtles in commercial fisheries along the coast of Maryland. Efforts such as this are crucial for determining the effects of commercial fisheries on marine mammal and sea turtle populations and should continue with greater intensity in the future. Federal efforts should be maintained and additional fisheries should be monitored in the mid-Atlantic region to provide more comprehensive data for management purposes. In addition, a state observer program should be created in which biologists could be trained as fisheries observers to document marine mammal and sea turtle bycatch (as well as other protected species) in state regulated fisheries that have been found to incidentally take these animals.

OBJECTIVE 3. Improve and increase law enforcement and regulation efforts.

Many regulations to protect marine mammals and sea turtles apply to the general public. However, much of the public is unaware of these laws and the penalties of violating them. In addition, the role of various Federal and state agencies in enforcing protective legislation are not clearly understood and many law enforcement personnel are unaware of this protective legislation.

3.1. Document and clarify existing legislation and regulations.

Existing legislation and regulations pertaining to marine mammal and sea turtle protection have been compiled and described in detail for the purposes of developing this conservation plan. A summary of Federal and state laws was described in the Jurisdiction and Regulations section of the document. It is the duty of each agency to inform and update the other agencies as new or additional information regarding their legal responsibility and authority becomes available.

3.2. Document and clarify agencies' responsibilities.

At the onset of this planning process, it became clear that the role and responsibilities of state and Federal agencies involved in the protection of marine mammals and sea turtles were not clear. One of the major goals during the development of this plan was to identify and delineate each agency's jurisdiction over these species. Existing legislation and regulations have been compiled and summarized in this conservation plan. In addition, the roles of each agency (NMFS, USFWS, NPS, USCG, and NRP) and the laws they can enforce in the protection of these species have been identified.

The next step is to more strongly enforce these laws, particularly the MMPA and ESA. Increased education of Federal, state, and local law enforcement officials about laws and regulations protecting marine mammals and sea turtles in Maryland will be helpful in this task. In addition, law enforcement efforts in Maryland waters would greatly benefit from increased cooperation and coordination among various agencies, including the NMFS, DNR (specifically the NRP), USCG, USFWS and AINS personnel. The NMFS should work closely with these agencies to improve and intensify law enforcement activities to curb the incidences of harassment and fisheries interactions in Maryland waters.

3.3. Identify ways to promote coordination and response.

Effective coordination and response between and among agencies and programs involved in marine mammal and sea turtle conservation in Maryland is crucial for the continuation of current efforts as well as the implementation of actions described in this plan. Contact persons from each agency or program should be designated to establish an effective communication network that can efficiently transfer information within an agency or program as appropriate. A list of these persons should made available to all agency and program staff. Information regarding strandings, enforcement issues, public outreach, etc. posted on email or a newsgroup could be directly and quickly accessed by all interested parties.

3.3.1. Develop and implement a violation enforcement and reporting action protocol.

A response plan should be developed to address the need for improved and effective law enforcement and violations reporting response. This plan should outline the proper steps for reporting a violation, investigating a violation of applicable laws, and taking law enforcement action when a violation is observed (e.g., issuing citations, arrests, etc). In addition, the plan should include a description of each law or regulation protecting marine mammals and sea turtles, the penalties of violating these laws and guidelines, guidelines for safely viewing these species, and each law enforcement agency's jurisdiction for enforcing regulations.

The NMFS toll free number to report violations should be included, as well as contact numbers for each law enforcement agency in Maryland (USCG, NPS, NRP). This information should be disseminated to all members of each agency and organization, key public officials, and various interested and affected groups, including commercial and recreational fishermen, beachfront landowners, boat/jet ski rental companies, sightseeing cruise companies, and Ocean City public works.

Objective 4. Identify, document and minimize impacts of commercial and recreational activities on sea turtles and marine mammals.

- 4.1. Develop and implement methods to reduce incidental take in commercial fisheries.
 - 4.1.1. Implement seasonal or geographic regulations for commercial fisheries with known impacts.

As stated earlier, preliminary observations and evidence suggest that marine mammal and sea turtle mortalities may coincide temporally and spatially with certain fisheries. If sufficient evidence for adverse effects is collected, existing seasonal or geographic regulations could be modified to reduce the incidental take of marine mammals and sea turtles with little or no impact on commercial catches of fish. However, changes in regulations will impact current and traditional fishing patterns and could affect the economic return from the fisheries. Therefore, this option should be weighed carefully before being implemented. Available data should be reviewed annually to determine when and where the likelihood for incidental take is greatest and to identify alternative areas or times in which those fisheries could operate.

Gear modifications should also be considered for fisheries in which the incidental take of marine mammals and sea turtles was correlated with specific gear types. Regulations relating to mesh size restrictions, reduced gear deployment time, restricted tow times, mandatory use of TEDs (see below), and the use of driftnets instead of anchor nets may minimize the impacts of commercial fisheries and dredge operations on marine mammal and sea turtle populations. Public meetings should be held to include fishermen in the discussion and development of potential gear modifications to reduce and eliminate incidental takes.

4.1.2. Monitor and reduce mortality from dredging activities.

Hopper dredging has been shown to be a major source of mortality for sea turtles along the southeastern coast of the United States (NRC 1990). The Virginia Institute of Marine Science recorded loggerhead mortalities from hopper dredges in the lower Chesapeake Bay in the spring of 1994 (Terwilliger and Musick 1995). Periodic dredging of navigation channels for maintenance purposes and offshore areas for beach restoration projects occurs in Maryland waters. As the result of Section 7 of the ESA, NMFS approved observers are required for most federal dredging projects along the Maryland coast to document sea turtle mortality in hopper dredges. When possible, dredging operations should be limited to the colder months (November to April) when sea turtles are uncommon or absent from Maryland waters. Sea grass beds, or SAVs, which are an important habitat for Kemp's ridleys and their prey (blue crabs), should also be protected from dredging.

In recent years the U.S. Army Corps of Engineers, in conjunction with the NMFS, has developed equipment enhancements to minimize or eliminate dredging mortalities. Gear specialists in Florida designed a sea turtle deflector device intended to push sea turtles out of the dredge path. This v-shaped deflector is attached to the hopper dredge drag head and internally reinforced. The deflector has been tested at several locations near Jacksonville, Florida and has an 80% protection efficiency. The success of these tests lead to the inclusion of the design as part of the Incidental Take Statement of the Regional Biological Opinion issued by the NMFS for hopper dredging along the southeastern United States coastline. As a result of these actions, the U.S. Army Corps of Engineers Jacksonville District now requires the deflector on all hopper dredging projects in that area. Deflectors should be mandatory on all dredging projects that may adversely affect sea turtles. The NMFS has required deflectors on several hopper dredging projects along the Maryland coast to minimize the risk of interaction with sea turtles in the dredge area. Cooperative efforts with the U.S. Army Corps of Engineers through support for dredge observers to document incidental take, biological surveys to estimate the abundance of sea turtles in proposed dredging areas, and field studies to test the effectiveness of sea turtle deflectors, are recommended.

4.1.3. Implement TED regulations for commercial trawlers with known impacts.

Currently, most shrimp and summer flounder trawlers operating in the southeastern United States are required to have a NMFS approved turtle excluder device (TED) installed in each net to provide for the escape of sea turtles. This device has been shown to be effective at excluding 97% of sea turtles with minimal loss of shrimp and other species. TEDs are not required on trawls in Maryland, although bycatch of sea turtles and endangered finfish have been documented in this gear. More information is needed on the trawl fishery in Maryland and its effects on sea turtles. Evidence may suggest the use of TEDs at specific locations and times of the year for trawl fisheries that have been shown to incidentally take sea turtles. The mandatory use of TEDs will be effective in reducing sea turtle mortality due to commercial fisheries in Maryland.

4.2. Identify, document, and minimize impacts of recreational activities.

In view of the observed and potential interactions between recreational activities and marine mammals and sea turtles (see Anthropogenic Factors section), research programs should be conducted to document and monitor these impacts in Maryland waters. In addition, protective measures should be developed and enforced where appropriate.

4.2.1. Development of marine mammal and sea turtle viewing guidelines and permits.

Although there are no commercial whale- or dolphin-watching operations located in Maryland, there are numerous sightseeing and nature tour boat companies that heavily advertise dolphin and sea turtle sightings. While these vessels are commercially registered with the Maryland DNR to operate in state waters, they are not required to acquire Federal or state permits for dolphin watching activities. There have been several unverified reports of tour boat companies harassing marine mammals along the Maryland coast. Although viewing guidelines have been

developed for the northeast and southeast regions of the United States (www.nmfs.noaa.gov/prot_res/MMWatch/MMViewing.html), there is little application of these guidelines in Maryland waters. Guidelines for safely viewing and operating around marine mammals and sea turtles should be implemented and enforced in Maryland waters. Manuals outlining the Federal laws protecting these animals, the viewing guidelines, and the fines associated with violating these laws could be developed and disseminated to tour boat operators and owners during the permitting or registration process. This information should also be distributed to the appropriate law enforcement agencies within Maryland. Tour boat companies that advertise marine mammal and sea turtle sightings should also be required to obtain a viewing permit from the state or federal government. In addition to developing and implementing viewing guidelines, studies should be conducted to assess the effects of directed vessel interaction on marine mammal and sea turtle behavior, injury, and mortality.

4.2.2. Enforce boating and jet ski regulations.

The dramatic increase in recreational boating traffic in Maryland waters in recent years has raised concerns about the potential impacts to marine mammals and sea turtles. Evidence of probable boat strikes and propeller wounds have been found on stranded marine mammals and sea turtles in Maryland. In addition, observations of fast moving jet skis harassing and pursuing marine mammals in waters along the Maryland coast have been reported. Research, including aerial surveys to document concurrent distribution of jet skis and marine mammals and sea turtles in Maryland waters, is needed to assess the impacts of these activities. Regulations should be developed and enforced where appropriate.

Speed restrictions should be implemented and enforced in areas where the potential for interactions between recreational watercraft and marine mammals and sea turtles are found to be high. Channels and seagrass beds are important foraging habitats for sea turtles in the Chesapeake Bay from May to October. Area and speed restrictions should be implemented in identified habitats during those months to reduce the potential for boat strikes. In March 2000, the National Park Service banned the use of personal watercraft from most waters around AINS in an attempt to reduce water and noise pollution. These restrictions may also help to minimize interactions between jet skis and marine mammals and sea turtles.

4.3. Develop and implement guidelines regarding marine mammal and sea turtle harassment and the possession of parts.

Although much of the general public is aware that marine mammals and sea turtles are protected species, they are unfamiliar with specific statutes that prohibit certain human-related activities. Specifically, the public is uninformed about regulations governing harassment and the possession of marine mammal and sea turtle parts found in the MMPA and the ESA. Interactions with the public at outreach events indicate that most are unaware that it is illegal to feed or swim with a wild dolphin or to take a sea turtle skull from the beach. Guidelines outlining the MMPA and ESA and the actions that are prohibited by these laws, including harassment and the possession of parts, should be developed. These guidelines could be distributed to the public at AINS entrance booths or displayed in the visitor center. Through a cooperative effort with boat rental companies, brochures could also be distributed to individuals renting jet skis or boats in Ocean City.

In addition, these brochures would be made available to the public at all outreach events, including Coast Days at Assateague Island and the Maryland State Fair.

4.4. Identify, document and minimize impacts of military activities.

The impacts of military activities on marine mammals and sea turtles in Maryland are unknown. The effects of target bombing, the use of sonar, and intense vessel activities (such as hovercraft) should be studied in the Chesapeake Bay and along the coast. Biologists from Maryland DNR and USFWS should work cooperatively with the Department of Defense and personnel from the various military bases within Maryland to conduct these studies.

OBJECTIVE 5. Establish cooperative research efforts in Chesapeake Bay and along Maryland coastline. Currently, there are limited marine mammal and sea turtle studies conducted in Maryland. Research efforts have been primarily restricted to data collected by the Maryland stranding network, bottlenose dolphin photoidentification surveys, satellite tagging of rehabilitated marine mammals and sea turtles at the NAIB, and EPA aerial surveys of the Atlantic coast. Clearly, there is a need for more intensive studies to acquire data on the life history, abundance, distribution, age-class structure, health, mortality, and genetic stock structure of marine mammal and sea turtle populations in Maryland waters. Collaborative research efforts between government agencies, academic institutions, zoos, aquariums, museums, and other conservation organizations within Maryland should be established to conduct these studies.

- 5.1. Collect life history information on marine mammals and sea turtles utilizing Maryland waters.
 - 5.1.1. Determine and monitor habitat utilization of marine mammals and sea turtles in Maryland waters.

Since 1989 the EPA has utilized aerial surveys to study marine mammal and sea turtle habitat utilization along the Atlantic Coast of the United States. However, data regarding habitat utilization in Maryland's Chesapeake Bay is generally lacking. Aerial surveys that include the Chesapeake Bay should be maintained and conducted year round when possible. The NAIB has satellite tagged several species of marine mammals and sea turtles including hooded, harbor, gray, and harp seals, harbor porpoises, a loggerhead sea turtle, and a West Indian manatee ("Chessie"), prior to their release from rehabilitation. The Aquarium has also placed a VHF radiotag on a pygmy sperm whale upon its release. These tagging efforts have provided important information on habitat use and migration routes of marine mammals and sea turtles in Maryland waters and elsewhere. More intensive tracking studies utilizing satellite, radio, and sonic telemetry of marine mammals and sea turtles should be undertaken to better define important habitats in Maryland waters. Overtime, recapture data from the sea turtle pound net tagging study in the Chesapeake Bay will provide information on distribution, migration, and habitat utilization by sea turtles in the state and elsewhere. Longterm boat based photoidentification surveys of bottlenose dolphins along the Maryland coast and in the Chesapeake Bay should be implemented to better define habitat utilization and to determine the location of calving and nursery areas.

5.1.2. Determine and monitor feeding ecology, both spatially and temporally, of marine mammals and sea turtles in Maryland waters.

The feeding ecology of marine mammals and sea turtles in Maryland has been studied by the stranding network since 1990. Stomach contents from stranded marine mammals and sea turtles are examined to determine food habits. This analysis has provided information on preferred prey species, as well as the ingestion of foreign matter such as plastic and fishing line. These efforts should be maintained and periodically analyzed and summarized for particular species. In addition, levels of prey abundance should be monitored using trawl surveys to identify trends in prey availability that might affect marine mammal and sea turtle populations.

5.2. Determine and monitor age class structure of marine mammals and sea turtles in Maryland waters (including reproductive rates).

Data on size, sex, and reproductive state are collected on dead stranded marine mammals and sea turtles in Maryland whenever possible. However, little is known of the age structure of these animals. Collaborative efforts are currently underway to analyze bone and teeth samples to determine the age of some dead stranded animals. These efforts should be maintained and the results should be reported in a timely manner. Information collected on the size and sex (using a testosterone assay) of sea turtles incidentally captured in pound nets will provide additional data to aid in estimating the approximate age class structure of sea turtles in Maryland. The incidence of bottlenose dolphin calves is recorded for aerial surveys when possible, and a photoidentification project should be undertaken to provide documentation of calf production by females. Photogrammetry, which utilizes vertical-aerial photography, can also be used to estimate the age structure and productivity (i.e. calf production) of populations of marine mammals (Cubbage and Calambokidis 1987; Ratnaswamy and Winn 1993). These methods may also be used to monitor calf production in large whales, such as humpbacks, off the coast of Maryland. The most effective methods for determining age-class structure should be identified and employed in long-term monitoring studies of marine mammals and sea turtles in Maryland waters.

5.3. Determine the genetic stock structure of marine mammals and sea turtles in Maryland waters.

Little is known of the genetic stock structure of sea turtles in Maryland. Blood samples collected from sea turtles incidentally captured in pound nets will be archived and analyzed to determine the genetic origin of sea turtles in the Chesapeake Bay. Skin samples from fresh, dead stranded sea turtles should be collected when possible. The genetic stock structure of marine mammals in Maryland is also unknown. Studies are needed for the two must abundant marine mammal species in Maryland, the harbor porpoise and bottle-nose dolphin. Biopsy sampling of cetaceans has been used successfully in genetic studies and could be utilized in research projects, such as photoidentification studies, in Maryland. Sick or injured cetaceans in rehabilitation at NAIB are sampled for genetics. This effort should be maintained and samples should be analyzed in a timely manner. Genetic analysis of skin samples collected from dead stranded marine mammals, including large whales, should be performed when appropriate.

5.4. Monitor relative abundance and distribution, both temporally and spatially, of marine mammals and sea turtles in Maryland.

Systematic surveys should be conducted to assess the abundance and distribution of marine mammals and sea turtles in Maryland waters. Existing methods of monitoring, including aerial surveys, satellite tagging and stranding network activities, should be maintained to establish population trends. Aerial surveys should be conducted year round and include the Chesapeake Bay. Overtime, recapture data from the sea turtle pound net tagging study will provide information on sea turtle distribution and abundance in the Chesapeake Bay. Long-term photoidentification studies are an extremely effective method for estimating population size and abundance of marine mammals. This type of study should be undertaken in Maryland waters to monitor marine mammal populations. The annual Dolphin Count, which occurs for one day every summer along the Atlantic coast from New Jersey to Florida, provides an estimate of abundance of bottlenose dolphins along the Maryland coast. This event, which encourages public participation and raises awareness, should be organized and carried out every year in Maryland.

5.5. Investigate health, disease, parasitism and contamination effects of marine mammals and sea turtles in Maryland waters.

Stranding personnel at COL and NAIB monitor the health of stranded marine mammals and sea turtles. Efforts to collect samples from dead animals for histopathology, microbiology, toxicology and parasite loads should be maintained and analysis of these tissues should be completed in a timely manner. Tissue samples should be sent to tissue banks to determine contaminant loads in marine mammals and sea turtles in Maryland. In addition, bloodwork and diagnostic procedures performed on marine mammals and sea turtles in rehabilitation provide important information about the health of these sick or injured animals. This information is necessary to make informed decisions about a course of treatment and to monitor the progress of an animal while in rehabilitation. The Aquarium also collects important information from satellite tags placed on released marine mammals and sea turtles. The tags produce dive data, which is an important indicator of an animal's general health and behavior. For example, long and frequent periods of time spent at the surface are abnormal, suggesting that an animal may be in poor health. In addition, recaptures of a tagged marine mammal or sea turtle overtime indicate survival of an animal, and therefore, a successful rehabilitation effort. The research conducted by the Maryland stranding network should be continued in cooperation with the NMFS, the Armed Forces Institute of Pathology, the Animal Diagnostic Laboratory and the Maryland Department of Agriculture.

Blood collected from sea turtles in the pound net tagging study will be analyzed to establish baseline health data for "normal," wild sea turtles in Maryland. Diagnostic tests will include complete blood count (CBC), health profile, serum chemistries, packed cell volume, total protein and sex determination (testosterone assay). Blood samples taken from wild, healthy turtles can be compared with those of turtles with unknown ailments through baseline analysis of their blood. This information could be useful to rehabilitation facilities (like NAIB) to establish guidelines for release criteria of stranded sea turtles. In addition, the blood could be screened for viruses, bacteria and parasites to indicate the health of the local population. This data could be important in identifying the cause of a mass stranding or a decline in the population in the region.

5.6. Determine and monitor mortality rates of marine mammals and sea turtles in Maryland.

Marine mammal and sea turtle mortality has been monitored as part of the stranding network in Maryland. Data collected from strandings includes the probable cause of death

when possible. Maryland stranding network efforts should be maintained and improved through the acquisition of funding to provide for additional state coverage, support and equipment. This information should be periodically compiled, summarized and presented to the NMFS, USFWS and Maryland DNR and at the Northeast Region Stranding Conference and Meeting held each spring.

OBJECTIVE 6. Improve and promote education and public outreach efforts.

Marine mammal and sea turtle conservation requires long-term public awareness and support over a large geographic area. The public must be informed of the issues and laws, particularly when conservation measures conflict with human activities such as commercial fisheries, recreational boating and beach restoration or development. Public education is essential to the success of a long-term conservation program in Maryland and elsewhere. Public outreach and education programs carried out by both government and non-governmental agencies and organizations in Maryland are achieving a level of awareness and support for marine mammal and sea turtle conservation. Such efforts must be maintained, expanded upon, and updated as new information becomes available. Areas in which public education and outreach efforts should focus include the following.

- 6.1. Identify ways to promote and improve information dissemination.
 - 6.1.1. Develop public service announcements regarding marine mammal and sea turtle conservation issues.

Professionally produced public service announcements for radio and TV would be effective for informing the public about current marine mammal and sea turtle issues such as harassment, entanglement, sea turtle nesting, and marine debris. In addition, the laws and regulations that protect these animals and the penalties for violating them (i.e., fines, jail time) could be reviewed. The announcements could also provide information on the Maryland stranding network, including the 1-800 number to report a stranding or sighting.

6.1.2. Post information signs on marine mammal and sea turtles issues at public access points.

Information signs on marine mammals and sea turtles should be posted at public access points, marinas, boat and jet ski rental company offices, boat ramps, and life guard stands in Ocean City and at the visitor center and ranger stations at AINS. These sites provide an opportunity to inform the public of necessary precautions for compatible use of the beach and ocean. The signs could include information outlining viewing guidelines (e.g., minimum viewing distances, no feeding or swimming), the MMPA and ESA (including the definition of the term "take"), the penalties of violating these laws (MMPA-up to \$20,000/1year in jail, ESA-up to \$50,000/1year in jail), the NMFS hotline number to report violations, and the 1-800 number to report a stranding or sighting.

6.1.3. Develop and distribute new educational and outreach materials.

Inventory existing and develop new materials regarding marine mammal and sea turtle ecology and conservation needs. The following topics have and should be addressed in these educational materials: 1) species identification for marine mammals and sea turtles in Maryland waters; 2) laws and regulations governing the protection of these species (including penalties for violations); 3) current con-

servation efforts within the state; 4) anthropogenic factors affecting these populations in Maryland waters; 5) marine mammal and sea turtle viewing guidelines; 6) Maryland stranding network efforts (including the 1-800 number); and 7) actions the public can take to help conserve marine mammals and sea turtles (throw away trash, view animals from a distance, report strandings, etc.).

This information can be compiled and distributed in a variety of forms including brochures, fact sheets, handbooks, posters, mail-outs, signs, videotapes, presentations, a traveling educational exhibit, education lesson plans, and kiosks. Dissemination of these materials to a variety of user groups (e.g., fishermen, boaters, commercial ship operators, volunteers, teachers, beachfront landowners, vacationers, etc.) is recommended to raise public awareness and support. Information could be distributed with boat registration applications (commercial and recreational), boat and jet ski rentals, camping reservation information, fishing regulations, on sightseeing cruises and at public outreach events throughout Maryland.

6.2. Incorporate a marine mammal and sea turtle educational curriculum into boater and PWC safety courses.

In recent years, there has been a dramatic increase in the number of registered boats and personal watercraft (PWC) in Maryland waters. This has lead to concerns about the effects of increased vessel traffic on marine mammal and sea turtle populations in Maryland waters. In addition, there have been several unconfirmed reports of marine mammal harassment along the coast. Currently, boater safety courses in Maryland do not include educational information on protected species awareness and conservation. A curriculum summarizing marine mammal and sea turtle harassment legislation, appropriate vessel operation in the vicinity of these animals, penalties of violating protective legislation and contact numbers to report harassment or strandings should be developed and included in boater and PWC safety courses in Maryland. The Virginia Marine Science Museum has recently implemented a similar project for Virginia boater safety courses. The purpose of this curriculum is to raise public awareness of harassment issues and teach boat operators to recognize and appropriately react around protected species. Perhaps in the future the state of Maryland will mandate vessel operator education courses for all licensed boaters, which would include information on appropriate vessel operation in the presence of protected species.

6.3. Provide training and educational workshops.

Workshops should be provided to collaborating agencies and organizations and a wide variety of affected parties to encourage their participation in conservation efforts in Maryland. In the past, COL has conducted sea turtle necropsy training workshops for several collaborating organizations to provide additional stranding support in southern Maryland. Such workshops and training should continue and involve other agencies and organizations. Additional workshops to improve marine mammal and sea turtle identification and provide for more accurate stranding reports should be developed. These workshops should focus on those groups most likely to encounter stranded animals, such as law enforcement officers, commercial fishermen, Federal and state field biologists, Ocean City Public Works and AINS park personnel. However, these workshops could also be conducted for local groups or organizations interested in becoming involved in protected species conservation.

6.4. Develop marine mammal and sea turtle education curriculum for agencies, organizations, schools and general public.

Staff from the education and outreach departments of the various agencies and organizations (MDDNR, USFWS, NMFS, NAIB, etc.) should work cooperatively to develop a marine mammal and sea turtle educational curriculum that would be made available to agencies, organizations and schools upon request. This curriculum should include information on marine mammal and sea turtle identification, biology, life history and status, protective legislation, anthropogenic factors, Federal and local conservation efforts, stranding network activities and list of ways to become involved in or contribute to marine mammal and sea turtle conservation in Maryland.

6.5. Identify ways to improve public participation.

Currently, there are several programs within Maryland that encourage public participation in marine mammal and sea turtle conservation efforts. The annual Dolphin Count day involves volunteers counting dolphins along the Maryland coast to provide an estimation of dolphin abundance during the summer. This event should be organized every year and advertised on television, in the newspaper and on the web sites of involved agencies and organizations (e.g., NAIB, COL) to promote participation by the public. The public can become involved with stranding activities by becoming a volunteer for the Marine Animal Rescue Program (MARP) at the National Aquarium in Baltimore. MARP volunteers respond to live strandings in Maryland waters and provide care for animals in rehabilitation.

Other programs that could be implemented to encourage public participation include the development of a volunteer program for the COL stranding network (described earlier) or a local area art contest on sea turtles and marine mammals. The artwork could be displayed at a public outreach event such as Coast Days or the Waterfowl Festival, and the winner's work could be featured on a conservation stamp or published in the Maryland Naturalist. The submitted artwork could also be used in a poster or calendar and sold as a fundraising product.

Table 1. Implementation Schedule for Marine Mammal and Sea Turtle Recovery Tasks

Task Name	Priority	Duration	Cost Estimates					Comments
	,		FY1	FY2	FY3	FY4	FY5	
1.1. Expand current necropsy facility	2	in progress	\$0	\$0	\$0	\$0	\$0	
1.2. Develop volunteer program	2	continuous	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	
1.3. Develop seal stranding protocol	2	in progress	\$0	\$0	\$0	\$0	\$0	
1.4. Develop sea turtle nesting protocol	2	update yearly	\$1,000	\$500	\$500	\$500	\$500	cost is for meetings, printing
1.5. Maintain database	2	ongoing	\$0	\$0	\$0	\$0	\$0	
1.6. Publish stranding data	2	every 5 yrs.	\$0	\$0	\$0	\$0	\$0	
2.1. Identify impacts of fisheries activities	1	5 yrs.	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	annual monitoring
2.2. Sea turtle tagging study	1	5 yrs.	\$46,000	\$50,000	\$50,000	\$50,000	\$50,000	Section 6 funds
2.3. Implement observer program	1	as warranted	?	?	?	?	?	cost depends on # of fisheries monitored
3.1. Clarify legislation	1	as needed	\$500	\$0	\$0	\$0	\$0	literature searches
3.2. Document agency responsibilities	1	update yearly	\$0	\$0	\$0	\$0	\$0	
3.3.1 Develop violation enforcement and reporting action plan	2	update yearly	\$1,000	\$500	\$500	\$500	\$500	publication costs
4.1. Reduce incidental take in commercial fisheries	1	5 yrs.	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	annual monitoring, gear modifications
4.2.1. Develop viewing guidelines and permits	2	update yearly	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	publication costs
4.2.2. Enforce boating regulations	2	ongoing	\$0	\$0	\$0	\$0	\$0	
4.3. Develop guidelines regarding harassment and possession of parts	2	update yearly	\$1,000	\$500	\$500	\$500	\$500	publication costs
4.4. Document military activities	1	2-3 yr. study	\$25,000	\$25,000	\$25,000			annual monitoring
5.1.1 Habitat utilization	1	5 yr. study	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	annual surveys
5.1.2.Feeding ecology	2	3-5 yr. study	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	annual surveys
5.2. Age class structure	2	5 yr. study	\$35,000	\$35,000	\$35,000	\$35,000	\$35,000	annual surveys
5.3. Genetic stock structure	1	5 yr. study	\$40,000	\$40,000	\$40,000	\$40,000	\$40,000	laboratory contract

Table 1 (cont.). Implementation Schedule for Marine Mammal and Sea Turtle Recovery Tasks

Task Name	Priority	Duration	Cost Estimates			Comments		
			FY1	FY2	FY3	FY4	FY5	
5.4. Monitor abundance and distribution	1	annual surveys	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	aerial surveys, etc.
5.5. Investigate health, disease, parasitism, contaminants	1	ongoing	\$40,000	\$40,000	\$40,000	\$40,000	\$40,000	MD stranding network
5.6. Mortality rates	1	ongoing	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	MD stranding network
6.1. Promote information dissemination	1	continuous	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	
6.2. Incorporate curriculum into boater safety courses	2	update yearly	\$5,000	\$1,000	\$1,000	\$1,000	\$1,000	publication costs
6.4. Develop education curriculum	2	continuous	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	update yearly
6.5. Improve public participation	1	continuous	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	

SHORTNOSE STURGEON

INTRODUCTION

The shortnose sturgeon, *Acipenser brevirostrum*, is a fish species that occurs in large coastal rivers of eastern North America, including the Chesapeake Bay and its tributaries. This species is listed as endangered under the Endangered Species Act (ESA) of 1973.

Section 4(f) of the ESA directs responsible agencies to develop and implement recovery plans for endangered species, unless such a plan will not promote the conservation of a species. Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect the species. Plans are prepared by the United State Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) and sometimes with the assistance of recovery teams, contractors, state agencies, and others.

A final recovery plan for the shortnose sturgeon was completed by the NMFS in December 1998. While this federal plan discusses what little is known about shortnose sturgeon populations throughout their range, is does not address the specific needs of this species in Maryland waters. Pollution, commercial and recreational fishing, bridge construction, dams, dredging, and power plant construction and operation are among the many factors that may vary between river systems where sturgeons are present. Therefore, in order to contribute to the overall recovery of the species, a state conservation plan is necessary to identify the sturgeon's specific needs and to manage and conserve the population in Maryland.

FUNDING

The development of this conservation plan is funded through Section 6 of the ESA. In general, Section 6 provides for cooperative agreements between the federal government (specifically the USFWS and NMFS) and states to share the responsibility of conservation within that state. States that enter into a Section 6 agreement must establish and maintain an adequate and active program for the conservation of endangered and threatened species.

The state of Maryland applied for a Section 6 agreement in 1992. Having successfully demonstrated the key elements (state laws, existing conservation programs, enforcement authority, and supervisory staff expertise) germane to the protection and conservation of endangered and threatened species the agreement was finalized in 1998. At this time, the state was awarded funds through Section 6 of the ESA to develop a conservation plan for marine mammals, sea turtles, and the shortnose sturgeon.

JURISDICTION AND REGULATIONS

Protective Legislation

Endangered Species Act (16 USC §1531-1544)

At the Federal level, efforts to protect endangered and threatened species began with the passage of the Endangered Species Preservation Act of 1966. The Endangered Species Conservation Act of 1969 strengthened these initial provisions but still had several weaknesses; it contained no prohibition on "taking" of endangered species, had no significant protection for habitat, and did little to address threats to individual populations that were endangered or threatened (Baur et al. 1999). Congress realized that a more comprehensive Federal effort was needed to protect and conserve species facing extinction. As a result, the Endangered Species Conservation Act was replaced by the much-strengthened Endangered Species Act in 1973. The ESA has as its main purpose to conserve the nation's natural heritage for the enjoyment and benefit of current and future generations. The ESA provides for the conservation of species that are in danger of extinction throughout all or a significant portion of their range and the habitats on which they depend. This law also prohibits the taking of an endangered species. Take is defined broadly and includes harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capturing, or attempting to engage in any of these activities.

An individual or organization may petition to have a species considered for listing as endangered or threatened under the Act. The listing of a species qualifies it for increased protective measures. Generally, the USFWS coordinates ESA activities for terrestrial and freshwater species, while the NMFS is responsible for marine and anadromous species. With the submission of a petition, the agencies must either reject the petition or accept it and conduct a status review of the species. The status review is initiated with solicitation of public information relevant to the species.

A species must be listed if it is threatened or endangered due to any of the following five factors:

- 1) present or threatened destruction, modification, or curtailment of its habitat or range;
- 2) over utilization for commercial, recreational, scientific, or educational purposes;
- 3) disease or predation;
- 4) inadequacy of existing regulatory mechanisms; or
- 5) other natural or manmade factors affecting its continuance or existence.

Once a species is listed, Section 4 of the ESA requires the development and implementation of recovery conservation plans to improve a species' status. The final recovery plan for the shortnose sturgeon was completed in 1998 (NMFS 1998c). Concurrent with the listing decision, critical habitat believed necessary for the continued survival of a species is designated. In addition, Section 7 of the ESA requires all Federal agencies to consult with the NMFS or the USFWS concerning any potential effects of their actions on a listed species. Ongoing consultation with other Federal agencies must minimize or mitigate potential impacts. For example, the USFWS and the NMFS recently conducted a study to determine the current status of sturgeons in the Potomac River, Maryland. The study resulted from concerns over the potential effect of an U.S. Army Corps of Engineers maintenance dredging project on shortnose and Atlantic sturgeons in the river (Eyler et al. 2000). The NMFS also reviews non-Federal activities that may affect listed species and issues Section 10 permits for incidental take.

The ESA provides fairly comprehensive protection by the USFWS and the NMFS for threatened and endangered species. In addition to Section 4, which allows for the recovery planning process, Section 6 provides for cooperative agreements between the Federal government and states to share the responsibility of conservation within that state. Agreements are established in states that develop and maintain conservation programs for endangered and threatened species. In Maryland, the Department of Natural Resources (DNR) has a Section 6 agreement with the NMFS to develop a conservation plan for sea turtles, marine mammals, and the shortnose sturgeon.

Lacey Act (16 USC §3371-3378)

Originally passed in 1900, the Lacey Act prohibits import, export, transportation, sale, receipt, acquisition, or purchase of fish, wildlife, or plants that are taken, possessed, transported, or sold in violation of any Federal, state, tribal, or foreign law. The Act has become a vital tool in efforts to control smuggling and trade of illegally taken fish, wildlife, and plants. The 1981 amendments to the Act were designed to strengthen Federal laws and improve Federal assistance to states and foreign governments in enforcement of fish and wildlife laws. The law covers all plants, fish, and wildlife, and their parts or products, protected by the Convention on International Trade in Endangered Species, and those protected by state law. The Lacey Act also regulates the transportation of live wildlife, requiring that animals in the United States be transported under humane and healthful conditions. However, it does not apply to interstate shipment of any fish, wildlife, or plant legally taken if the shipment is en route to a state in which the fish, wildlife, or plant may be legally possessed. The Secretary of the Interior is authorized to designate those wildlife species considered injurious to humans, agriculture, wildlife resources, or otherwise, and prohibit their importation into the United States.

Pursuant to this Act, the Secretary of Commerce may make available rewards to individuals who provide information leading to arrests, criminal convictions, civil penalties, or the forfeitures of property. Individuals convicted of violating the Lacey Act may be sentenced up to \$100,000 and one year in jail for misdemeanors and up to \$250,000 and five years in jail for felony violations. Fines for organizations in violation of the Lacey Act are up to \$250,000 for misdemeanors and \$500,000 for felony violations. In addition, officers enforcing the Act are authorized to inspect vessels, vehicles, aircraft, packages, crates, and containers upon arrival in or prior to departure from the United Sates and to seize all vessels, vehicles, aircraft, and other equipment used to aid in criminal violations of this Act.

NMFS special agents enforce the Lacey Act against foreign-flagged vessels that fish illegally in the EEZs of South Pacific Island countries and import the fish into Guam and American Samoa. In addition, the NMFS enforces this Act against United States fishermen who operate illegally in foreign waters, such as the Bahamas. NMFS agents work cooperatively with state natural resource officers to apprehend poachers who take contaminated shellfish from closed state waters and subsequently ship those illegal products in interstate commerce.

Anadromous Fish Conservation Act (16 U.S.C. 757a-757g; Public Law 89-304, as amended)

The Anadromous Fish Conservation Act was passed in 1965. This Act authorizes the Secretaries of Interior and Commerce to enter into cooperative agreements with states and other non-federal interests for the conservation, development, and enhancement of anadromous fish, including similar species in the Great Lakes and Lake Champlain. The laws permits investigations, engineering and biological surveys, research, stream clearance, construction, maintenance, and operation of hatcheries, and devices and structures for improving movement, feeding, and spawning conditions. After this data is collected, the Secretary makes recommendations concerning measures for eliminating or reducing polluting substances detrimental to fish and wildlife in interstate or navigable waterways. All projects must be cleared with the fishery agency of the state where the proposed work will be conducted. Many projects funded under this program are critical elements of large, multi-funded programs to manage, restore, or enhance anadromous species such as Pacific and Atlantic salmon, Atlantic and shortnose sturgeons, American shad, and river herring. Shortnose sturgeon projects, including distribution, abundance, movement, and restoration studies in the Connecticut, Thames, and Delaware rivers, have been funded by the NMFS under this law.

Maryland Endangered Species Act

The Maryland Endangered Species Act of 1971 (Article 66C, Section 125, Annotated Code of Maryland) became the first piece of state legislation protecting endangered species in Maryland. The law prohibited the taking, transportation, possession, processing, or sale within the state of Maryland of any wildlife appearing on the Federal lists of endangered, foreign or native fish and wildlife. It also mandated the Secretary of the DNR to develop a list of fish and wildlife deemed to be threatened with statewide extinction and provided full protection for those species. The first state list of endangered species was promulgated in 1972 and consisted of twenty-one species. The Maryland Endangered Species Act was revised in 1973. The revision consisted mostly of a clarification of language; the substance of the original act was retained.

In 1975 the Maryland Nongame and Endangered Species Conservation Act (Natural Resources Article, §10-2A, Annotated Code of Maryland) was passed, replacing the revised Endangered Species Act of 1973. This act mandated the investigation, management, and protection of both nongame wildlife and threatened and endangered species of wildlife and plants. Under this act, the DNR is authorized to enter into agreements with federal agencies, other states, Maryland political subdivisions, and individuals and to establish programs (including acquisition of land or aquatic habitat) necessary for the conservation of listed species. It also established a consultation process whereby all state cabinet level departments were to consult with the Secretary of Natural Resources to further programs for threatened or endangered species and minimize the effects of their actions that might jeopardize the existence of these species. The

Nongame and Endangered Species Conservation Act is the primary State law that allows and governs the listing of endangered species in Maryland. The Act is supported by regulations (Code of Maryland Regulations or COMAR, 08.03.08) that contain the official State Threatened and Endangered Species list. In addition, all Federally listed species are automatically listed in Maryland (Nat. Res. Art., §10-2A-04a). Violations of the Nongame and Endangered Conservation Species Act are misdemeanors punishable by fines up to \$1000 and/or imprisonment of one year.

Maryland Endangered Species of Fish Conservation Act

The other main statute providing protection for threatened and endangered species in Maryland is the Endangered Species of Fish Conservation Acts of 1975 (Nat. Res. Art., §4-2A, Annotated Code of Maryland). This act governs the regulation and care of threatened and endangered fish species in Maryland through many of the same actions as the Nongame and Endangered Species Conservation Act (see above). All Federally listed species are automatically listed in Maryland (Nat. Res. Art., §4-2A-04a). The DNR's Fisheries Service maintains an official list of game and commercial fish species that are designated as threatened or endangered in the state (COMAR 08.02.12.01). Violations of the Endangered Species of Fish Conservation Act are misdemeanors punishable by fines up to \$1000 and/or imprisonment of one year. They may also result in the seizure of fishing licenses and confiscation of fish, gear, equipment, and vessels used in fishing activity (COMAR 08.02.12.02).

FEDERAL CONSERVATION AUTHORITIES

National Marine Fisheries Service and United States Fish and Wildlife Service

The USFWS and NMFS share responsibility for the administration of the ESA. The USFWS originally listed the shortnose sturgeon as an endangered species in 1967 under the Endangered Species Preservation Act. The Department of Commerce, National Oceanic and Atmospheric Administration, NMFS, later assumed jurisdiction for shortnose sturgeons under a 1974 government reorganization plan (NMFS 1998c). The NMFS has responsibility for most marine and anadromous species, including the shortnose sturgeon. This agency bears the responsibility for conservation of shortnose sturgeons through direct legislative mandates and partnerships with state, Federal (particularly the USFWS), and private organizations, the fisheries industry, and the general public.

STATE CONSERVATION AUTHORITIES

Maryland Fisheries Resource Office, United States Fish and Wildlife Service, Annapolis, MD

The USFWS has offices in every state and many territories of the United States. The list of federal laws under which the USFWS functions is extensive and includes the Marine Mammal Protection Act, ESA, Anadromous Fish Conservation Act, and the Lacey Act. The Maryland Fisheries Resource Office (MFRO), located in Annapolis, Maryland, is a component of the USFWS. The MFRO coordinates fish tagging programs in cooperation with federal and state agencies along the eastern seaboard. Information from these tagging programs can be used to monitor the status of stocks, restore fish populations, and set seasons on harvests. Current projects include American shad (since 1995), horseshoe crab (since 1999), and striped bass (since 1985) cooperative tagging programs and a sturgeon reward program. In 1996 the USFWS, Maryland DNR, and the Chesapeake Bay Foundation started a live sturgeon reward program in Maryland waters of the Chesapeake Bay. Watermen are asked to hold alive any sturgeon incidentally captured in their fishing gear and to contact the MFRO via a toll free telephone number. MFRO biologists respond to the site of the held sturgeon to measure, weigh, tag, and remove a tissue sample from the fish before releasing it. Watermen receive a reward of \$100 if the fish is a wild sturgeon and \$25 if it is one of the tagged, hatchery-reared Atlantic sturgeons released into the Nanticoke River in July 1996. In addition to the live reward program, the MFRO initiated two gill net studies to determine if sturgeons use areas of proposed dredge and fill operations in the upper Chesapeake Bay and Potomac River (Eyler et al. 2000; Skjeveland et al. 2000). The studies included the use of telemetry to track movements of sturgeons in the Chesapeake Bay, and these efforts continue with financial support from the U.S. Army Corps of Engineers. The data collected in these programs provide important information such as movement patterns,

distribution, growth, habitat use, and mortality of sturgeons. This information is essential to determine the population status of the endangered shortnose sturgeon in the Chesapeake Bay.

Maryland Department of Natural Resources

At the state level, the Maryland DNR oversees the management and use of the living and natural resources of the Chesapeake Bay and its tributaries. DNR has broad responsibility to conserve threatened and endangered species. As described earlier, the two statutes which govern the regulation and care of these species are the Maryland Endangered Species of Fish Conservation Act (Nat. Res. Article, §4-2A, Annotated Code of Maryland) and the Maryland Nongame and Endangered Species Conservation Act (Nat. Res. Article, §10-2A, Annotated Code of Maryland). In these acts "conserve" is defined as the means to use all methods and procedures for the purpose of increasing the number of individuals within species or populations up to the optimum carrying capacity of their habitat and maintaining these levels. These methods and procedures include activities associated with resource management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation, including the protection of species or populations as well as regulated taking.

The laws also direct the DNR to determine, using specified factors, whether a species of fish or wildlife normally occurring within the state is threatened or endangered. These factors include present and threatened destruction of a species' habitat or range, overutilization for commercial, sporting, scientific, educational or other purposes, and disease or predation (Nat. Res. Article, §4-2A-04 and §10-2A-04, Annotated Code of Maryland). The DNR is authorized to adopt rules and regulations to provide for the conservation of endangered and threatened species, to establish programs, including the acquisition of land or aquatic habitat, necessary for the conservation of listed species, and to enter into agreements with Federal and state agencies, Maryland political subdivisions, and individuals to conserve listed species. All state agencies are directed to utilize their authorities in furtherance of the Acts and carry out programs for the conservation of threatened and endangered species.

The Maryland DNR, specifically the Fisheries Service, participates in sturgeon conservation efforts within the state. In July 1996, the DNR and the USFWS released 3,000 tagged, hatchery-reared Atlantic sturgeons into the Nanticoke River as part of a restoration effort to enhance the Chesapeake Bay sturgeon population. Since stocking in 1996, the DNR has been working with the USFWS MFRO to tag sturgeon incidentally captured in commercial fishing gear as part of the sturgeon reward program. The Department is also involved in developing a captive population of Atlantic sturgeons to use as broodstock for a stocking program in Maryland.

COLLBORATING AGENCIES

In addition to the mandated conservation programs of the Federal and state agencies discussed above, several other organizations contribute to shortnose sturgeon conservation efforts in Maryland and should be recognized. Summarized below are the major partners who actively participate in Maryland's shortnose sturgeon conservation programs, particularly through cooperative efforts related to the live reward program.

United States Army Corps of Engineers, Baltimore District, MD

The U.S. Army Corps of Engineers (ACOE) is responsible for maintenance dredging of navigational and shipping channels in the Chesapeake Bay. Several projects have raised concerns about the potential effects of dredge and fill operations on shortnose sturgeon habitat in these areas. Therefore, pursuant to Section 7 of the ESA, the ACOE contracted the USFWS (specifically the Maryland Fisheries Resource Office) to examine sturgeon use of potential dredge spoil disposal areas in the upper Chesapeake Bay and Potomac River (Eyler et al. 2000; Skjeveland et al. 2000). This work included telemetry studies to track sturgeon movements in the Chesapeake Bay and through the Chesapeake and Delaware (C&D) canal. The

ACOE funded both of these studies and continues to provide financial support for telemetry studies in these locations.

Maryland Port Administration, Baltimore, MD

The Maryland Port Administration (MPA) is one of five agencies within the Maryland Department of Transportation. The MPA is charged with stimulating the flow of waterborne cargo through the entire Port of Baltimore community, maintaining the terminals, and marketing the Port of Baltimore worldwide. The Port of Baltimore was founded in 1706 and has grown to become one of the busiest ports on the East Coast of the United States. The MPA provides financial support for the USFWS and Maryland DNR sturgeon reward program.

United States Geological Survey, Biological Resources Division, Kerneysville, WV

The Biological Resources Division (BRD), formerly the National Biological Service, has been part of the U.S. Geological Survey (USGS) since 1996. The majority of BRD programs and resources are directed towards the needs and responsibilities of Interior resource management bureaus, such as studies supporting the development of waterfowl regulations, research leading to better land protection strategies in national parks, and investigations to determine optimal water control practices for the enhancement of fisheries. The BRD develops partnerships with Federal and state agencies and outside organizations to share information necessary to support the effective management and conservation of our Nation's biological resources. One of the current research areas of the BRD is stock identification of North American anadromous fish, including sturgeons. Tissue samples are collected from sturgeons captured in the live reward program and in gill net studies to determine the genetic stock of the Chesapeake Bay population. The samples are sent to Dr. Tim King at USGS-BRD Kerneysville, WV, for genetic analysis using a cellular DNA (microsatellite) method. The USGS-BRD is also assisting the Maryland DNR in developing a genetic database for sturgeons.

Chesapeake Bay Foundation, Annapolis, MD

The Chesapeake Bay Foundation (CBF) is a private sector organization formed in 1967 by a group of Baltimore businessmen. Since that time, CBF has expanded throughout Virginia, Delaware, and Pennsylvania, membership has grown to more than 80,000 individuals, and the staff number 150. At the onset of the sturgeon reward program in 1996, the CBF contributed funds to support the monetary rewards offered to commercial watermen for live sturgeon incidentally captured in fishing gear.

Nelson Institute of Environmental Medicine, New York University Medical Center, Tuxedo, NY

Founded in 1947, the Nelson Institute of Environmental Medicine at New York University Medical Center is one of the nation's oldest and foremost centers for research into the health effects of environmental pollution. The Nelson Institute is both a department in the New York University School of Medicine and an institute within the New York University Medical Center. Tissue samples collected from shortnose sturgeons captured in the reward program or collected by researchers are sent to Dr. Isaac Wirgin at the Nelson Institute for mitochondrial DNA analysis (PCR and direct sequencing). Analysis of samples collected from shortnose sturgeons in the upper Chesapeake Bay and Delaware River between 1996 and 2000 showed no significant haplotype differentiation between the two populations (Grunwald et al. submitted).

Department of Defense Aberdeen Proving Grounds, Aberdeen, MD

The Department of Defense Aberdeen Proving Grounds (APG) was established in 1917, making it the Army's oldest active proving ground. As a center for Army material testing, laboratory research, and military training, the post is a key element in the nation's defense. Its northernmost point is marked by the confluence of the Susquehanna River and the Chesapeake Bay. The Gunpowder River borders the grounds on the south. In 1997, the Aberdeen Proving Grounds, in collaboration with the USFWS, funded a shortnose sturgeon gill net study in restricted waters around Pooles Island and in the Gunpowder River.

The APG performed this study to fulfill their responsibility to document and manage any rare, threatened, or endangered species that exist within their boundaries. Some of the study sites were later incorporated into the larger gill net study initiated by the USFWS in 1998 to determine if sturgeons use areas of proposed dredge and fill operations in the upper Chesapeake Bay.

Commercial Watermen, Chesapeake Bay, MD and Potomac River, VA

The success of the sturgeon reward program is dependent upon the cooperation and assistance of commercial watermen in the Chesapeake Bay and its tributaries and the Potomac River. Watermen are asked to hold alive any sturgeon incidentally captured in their fishing gear and to contact the MFRO via a toll free telephone number. Watermen receive a reward of \$100 for wild sturgeons and \$25 for tagged, hatchery-reared Atlantic sturgeons.

BIOLOGICAL CHARACTERISTICS

Species Description

The sturgeon family (Acipenseridae) is among the most primitive of the bony fishes. Generally, adult sturgeons are heavy, subcylindrical fishes with an elongated, hard snout and a distinctly ventral, protruding mouth (Gilbert 1989). A row of barbels extends across most of the width of the snout and is situated midway between the mouth and tip of the snout. Sturgeons have a strong heterocercal tail in which the upper lobe of the tail fin is longer than the lower lobe and contains the extended vertebral column. The head is covered by bony plates, and the remainder of the body has five rows of large, bony scutes (one dorsal, two lateral and two ventrolateral rows). The dorsal and anal fins are approximately opposite from each other and are situated far back on the body (Gilbert 1989).

The shortnose sturgeon, Acipenser brevirostrum, is the smallest of the three sturgeon species that occur in eastern North America. Adults reach a maximum length of about 4 feet (120 cm) and a weight of 24 kg. Growth rate and maximum size vary with latitude, with the fastest growth occurring among southern populations. Maximum known age for females is 67 years, but males seldom exceed 30 years of age (Dadswell et al. 1984; Kynard 1997). There is little sexual dimorphism in shortnose sturgeons, although females grow to a larger size than males. They resemble similar-sized juvenile Atlantic sturgeon (A. oxyrinchus oxyrinchus) that historically co-occurred in the same waters along the East Coast of the United States. The shortnose sturgeon is distinguished from the Atlantic sturgeon by a wider mouth (width of inside lips is greater than 62% of bony interorbital width), a shorter and blunter snout, and the absence of bony plates along the base of the anal fin (Dadswell et al. 1984; NMFS 1998c). Adult shortnose sturgeons have a yellowish brown body with a green or purple cast. The head, back, and sides (level to the lateral plates) are nearly black in color and become white to yellow ventrolaterally. The barbels and ventral surface of the body are white. All of the fins are pigmented, and the paired fins are outlined in white. Adult shortnose sturgeons have 7 to 13 dorsal scutes, 21 to 35 lateral scutes, and 6 to 11 ventral scutes (Dadswell et al. 1984). The pigmentation of the scutes is much paler than the background, making the scute pattern obvious (Gilbert 1989). The crescentic trailing edge of the single dorsal fin has 38 to 42 rays and the emarginate trailing edge of the anal fin has 18 to 24 rays (Dadswell et al. 1984; NMFS 1998c). The paired fins, located anterior to the anal fin, have a heavy ossified first ray (Dadswell et al. 1984). Shortnose sturgeons have no lateral line.

Distribution and Population Size

Shortnose sturgeons are found in most major river systems along the eastern seaboard of North America. Historically, their distribution extended from the Saint John River, New Brunswick, Canada, to the Indian River, Florida (NMFS 1998c). They are anadromous, living mainly in the slower moving waters of their natal river or nearshore marine waters, and migrating into faster moving freshwater areas to spawn. Unlike other anadromous species such as shad or salmon, the shortnose sturgeon does not appear to make long distance offshore migrations. The NMFS currently recognizes 19 population segments occurring in New Brunswick, Canada (1), Maine (2), Massachusetts (1), Connecticut (1), New York (1), New Jer-

sey/Delaware (1), Maryland/Virginia (1), North Carolina (1), South Carolina (4), Georgia (4) and Florida (2) (NMFS 1998c). Currently, sturgeon populations from the Chesapeake Bay to Cape Fear River, North Carolina are scarce, although historically populations were likely present in all large rivers in this area (Kynard 1997). For the river systems in which population estimates are available, the smallest number of adult fish are found in the Merrimack (Massachusetts; <100 adults) and Cape Fear (North Carolina; <100 adults) rivers, while the largest numbers occupy the Hudson (New York; >38,000 adults) and Saint John (New Brunswick; ~18,000 adults) rivers (NMFS 1998c).

The population size and distribution of shortnose sturgeons in the Chesapeake Bay are largely unknown. The first published account of a shortnose sturgeon was in the Potomac River in 1876 (NMFS 1998c). Most historical records are from the upper Chesapeake Bay, with one record from the mouth of the Rappahannock River in Virginia (Skjeveland et al. 2000). Since the implementation of the sturgeon reward program in 1996, shortnose sturgeons have been reported in the upper Bay, from Kent Island to the mouth of the Susquehanna River and the C&D Canal, in Fishing Bay and around Hoopers Island in the middle Bay, and in the Potomac River (Skjeveland et al. 2000).

Life History

Length at maturity (45-55 cm Fork Length, FL) is similar throughout the shortnose sturgeon's range, but fish in southern rivers mature at a younger age because they grow faster than those in northern rivers (Kynard 1997). Males mature at 2 to 3 years in Georgia, 3 to 5 years in South Carolina, and 10 to 11 years in the Saint John River, Canada (Dadswell et al. 1984). Females require longer to mature, ranging from 4 to 5 years in Georgia, 7 to 10 years in the Hudson River, and 12 to 18 years in the Saint John River. First spawning occurs 1 to 2 years after maturity in males and up to 5 years in females (Dadswell 1979). Spawning periodicity is poorly understood, but males seem to spawn more frequently than females. Dadswell (1979) estimated that males in the Saint John River spawned at 2-year intervals and females at 3-5 year intervals. However, annual spawning by some males has been documented in the Merrimack, Connecticut, and Hudson rivers (Kieffer and Kynard 1996; NMFS 1998c).

Shortnose sturgeons use a wide variety of habitats and variations occur latitudinally, seasonally, and among different life stages. Prior to spawning, some populations of adult shortnose sturgeons will congregate in overwintering sites near the spawning grounds until spring (Bain 1997). The spawning migration is characterized by rapid, directed, and often extensive movement upstream (up to 200 km in some populations; Hall et al. 1991; NMFS 1998c). Spawning occurs between February and May depending on latitude (late winter, southern rivers; mid-spring, northern rivers), when river temperatures increase to about 9° C. Spawning usually ceases between 12-15° C (Dadswell et al. 1984). In some rivers, spawning occurs during or after peak spring flows (Kynard 1997). Shortnose sturgeon spawning grounds are located well upstream from summer foraging and nursery grounds in areas of relatively fast flowing freshwater with gravel, boulder, or rubble bottoms. Channels are important spawning grounds for shortnose sturgeons in many rivers. The spawning period is estimated to last from a few days to several weeks and the ratio of sexes on the spawning grounds is typically 2.5 males to 1 female (Dadswell et al. 1984; NMFS 1998c). Males fertilize the eggs as they are released into flowing water close to the substrate. The eggs become strongly adhesive within twenty minutes of fertilization and attach to rocks, weeds, and other submerged objects (Gilbert 1989). Shortly after spawning, most shortnose sturgeons move downstream and spend the rest of the year in the lower parts of rivers and in estuaries. These migrations downstream usually occur from April to June depending on latitude (Gilbert 1989).

Shortnose sturgeon eggs hatch in 8 days at 17°C and 13 days at 10°C (Dadswell et al. 1984). At hatching, a shortnose sturgeon is black in color, 7-11 mm long, and resembles a tadpole (NMFS 1998c). Hatchlings have a large yolk sac, poorly developed eyes, mouth, and fins, and can only swim using swim-up and drift behavior (Richmond and Kynard 1995). They are photonegative and actively seek cover under any available structure in spawning areas. In 9-12 days hatchlings absorb the yolk-sac and develop into larvae at

about 15 mm total length (TL). Larvae have well-developed eyes, a mouth with teeth, and fins that enable them to swim normally. At 20 mm TL larvae begin exogenous feeding, are photopositive, and swim in the water column. In the laboratory, larvae were nocturnal and preferred white substrate, deep water, and a silt bottom (Richmond and Kynard 1995). In the wild, larvae of this size probably begin to migrate downstream. Kynard (1997) found that in the laboratory migration downstream is a two-step process: the first migration ceases after two days, followed by a residency period of young-of-the-year (YOY) sturgeon, then a resumption of migration by yearlings in the second summer of life. Data collected from rivers throughout the sturgeon's range suggest that YOY remain in fresh water for about one year before moving downstream to the fresh-saline water interface. YOY are 14-30 cm TL after the first year.

Juveniles (3-10 years old) occur at the fresh-saline water interface in most rivers and are essentially nonmigratory. Generally, they move to and from freshwater for a number of years before entering the marine environment and joining the adult migration pattern (Kieffer and Kynard 1993). More specifically, juveniles shift upstream in spring and summer and downstream in fall and winter, but these movements usually occur in the low salinity portion of the salt wedge, or just above the fresh-saline water interface (Dadswell et al. 1984; NMFS 1998c). Habitat use by juveniles has been studied in several rivers. Juveniles in the Saint John, Hudson, and Savannah rivers use sand and mud substrate in deep channels, while juveniles in the Ogeechee River moved into more saline waters (0-16 ppt) when the water temperature dropped below 16°C (Halle et al. 1991; Dovel et al. 1992; NMFS 1998c).

Generally, adult sturgeons are found in freshwater or freshwater/tidal reaches of rivers in the summer and winter. There appears to be a latitudinal pattern in the amount of time spent in salt water, with northern and southern populations using saline waters to a greater extent than mid-Atlantic populations (Kynard 1997). Shortnose sturgeons in some northern rivers exhibit freshwater amphidromy, in which a species spawns and remains in freshwater for most of their life cycle, but spends some time in saline water. Adult sturgeons in the Saint John, Connecticut, and Merrimack rivers remain in freshwater for years, but each year some fish spend time in saline water (Buckley and Kynard 1985; Kieffer and Kynard 1993). In north-central rivers (Merrimack River to the Delaware River) adults remain in freshwater all year, leaving only to spawn upriver or to move briefly downstream to saline water following the spawning period. Shortnose sturgeons in many southern rivers are estuarine anadromous. Adults are found upstream during February and March while spawning but spend the remainder of the year at the interface of fresh tidal water and saline estuaries (Dadswell et al. 1984; Hall et al. 1991; Moser and Ross 1995). The adaptive significance of the unusual latitudinal variation in the degree of anadromy between northern and southern populations is unknown but may be related to the availability and abundance of food resources or suitable water quality (Kieffer and Kynard 1993).

Shortnose sturgeons are continuous benthic feeders. They feed on crustaceans, insect larvae, worms, and mollusks. However, they apparently undergo ontogenetic shifts in preferred food items. Juveniles feed predominately upon insect larvae and small crustaceans (amphipods, isopods) while adults feed primarily on small mollusks (Dadswell et al. 1984; NMFS 1998c).

Status

More than a century of extensive fishing contributed to the decline of shortnose sturgeon populations along the East Coast of the United States. During the twentieth century heavy industrial development reduced water quality in rivers inhabited by sturgeon and hindered species recovery. Today, habitat degradation resulting from dams, bridge construction, channel dredging, and pollutant discharges and mortality from impingement on cooling water intake screens, dredging, and incidental capture in commercial fisheries are the principal threats to the species' survival (NMFS 1998c). The shortnose sturgeon was listed as endangered on March 11, 1967 under the Endangered Species Preservation Act (32 FR 4001). The species remained on the endangered species list with the enactment of the ESA in 1973. This status was adopted by the Maryland DNR through the Maryland Endangered Species Act of 1971 and the

shortnose sturgeon was included in the first state list of endangered species in 1972 (COMAR 08.03.08.04; Taylor 1984).

FACTORS AFFECTING RECOVERY

The USFWS identified pollution and overharvesting in commercial fisheries as reasons for initially listing the shortnose sturgeon as endangered in 1967. However, other activities, left unchecked, may also contribute to the decline and impede species recovery. Biological characteristics of the shortnose sturgeon, such as slow growth, advanced age at maturation, and long periods between spawning, cause the species to be particularly vulnerable to overfishing and human induced changes to their habitat. As the result of Section 7 consultations mandated by the ESA to assess the impact(s) of federal projects on shortnose sturgeons, the NMFS obtained valuable information regarding the extent to which activities such as commercial fishing, dredging, pollutant discharges, bridge construction and removal, dam construction, and power plant operation may affect this species and its habitat. However, in many cases data are inconclusive to establish a direct relationship between human activities and impacts to the sturgeon population; more research is needed in many areas. The results of the assessments were summarized in the Shortnose Sturgeon Recovery Plan drafted by the NMFS in 1998. The Recovery Plan findings are reviewed below, as well as available information pertaining to factors affecting shortnose sturgeons in the Chesapeake Bay.

Anthropogenic Factors Commercial Fisheries

Historically, Native Americans harvested sturgeon for caviar and meat (Hildebrand and Schroeder 1928). Commercial exploitation of shortnose sturgeons occurred throughout their range in colonial times and continued periodically into the 1950s. During the 17th century sturgeon meat, eggs, and oil were exported to the European market (Van den Avyle 1984). Sturgeon caviar was the first significant cash crop exported to Europe from the Chesapeake Bay area. Beginning in the middle of the 19th century, sturgeons were processed for caviar in the United States, but the demand remained small until 1870, after which the industry expanded rapidly. By 1880, major commercial fisheries were established along much of the Atlantic coast including New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia (Smith 1985). The harvest reached a high of 7 million pounds for all the states in 1890, although Atlantic and shortnose sturgeons were not differentiated in these historical fishing records (Gilbert 1989). The Delaware Bay area was the center of the sturgeon industry on the Atlantic coast, with annual commercial catches ranging from 4.9 to 6.5 million pounds between 1887 and 1892. The Chesapeake Bay supported the second largest caviar fishery, with a record high of more than 700,000 pounds in 1890. The Potomac River sustained the largest catches of sturgeons in Maryland waters during this time (Hildebrand and Schroeder 1928). However, intense fishing pressure to meet caviar demands devastated the sturgeon population along the Atlantic coast. By the turn of the century stocks began to collapse, as indicated by the low harvest of 22,000 pounds in 1920 (Smith 1985). Commercial landings of sturgeons in the Delaware Bay and Chesapeake Bay declined by more than ninety-five and ninety percent, respectively, between 1891 and 1901 (Gilbert 1989).

The directed harvest of shortnose sturgeons was banned when the species was listed as endangered in 1967. However, this species occurs as bycatch in other anadromous fisheries across its range. Adults are especially vulnerable to fishing gears during their extensive migration up- and downstream. Commercial and recreational shad fisheries operating in the Merrimack, Connecticut, Hudson, Delaware, and Cape Fear rivers and various rivers in South Carolina and Georgia are known to incidentally capture shortnose sturgeons (NMFS 1998c). The shad gill net fishery accounts for 83% of shortnose sturgeon takes in Georgia coastal fisheries and in a South Carolina study 16% of 51 sturgeons (41 Atlantic and 11 shortnose) incidentally captured in gill nets died and 20% percent were injured (Collins et al. 1996). The number of lethal takes in northern rivers is estimated to be about 20 fish per year (NMFS 1998c). Shortnose sturgeons are incidentally taken in shad, salmon, striped bass, and alewife fisheries in the Saint John

River estuary, but in most cases the fish are returned to river, reportedly unharmed (NMFS 1998c). However, studies suggest that extensive handling or repeated capture may result in disruption or even abandonment of spawning migrations (Moser and Ross 1993, 1995). Shortnose sturgeons are occasionally a bycatch of commercial fisheries in the Chesapeake Bay. Small numbers of incidental takes have occurred in eel pots, pound nets, fyke nets, catfish traps, hoop nets, and gill nets in the upper and middle Chesapeake Bay and the Potomac River (Eyler et al. 2000; Skjeveland et al. 2000). In addition to accidental mortality, poaching of shortnose sturgeons is known to occur. For example, about 50 sturgeon (20-50% of estimated annual spawning aggregation) from the Cooper River, South Carolina, were taken by a single group of poachers in 1995 (Collins et al. 2000).

Bridge construction and demolition

Bridge construction and demolition may interfere with shortnose sturgeon migratory movements and disturb areas of high sturgeon concentrations. However, data on these potential effects is generally lacking. The construction of a new bridge upstream of sturgeon spawning habitat in the Connecticut River raised concerns about the effects of fine sediment build up on egg survival in the spawning site. However, studies demonstrated that fine sediments were cleanly dislodged from the spawning site during the high spring flood (NMFS 1998c). The use of powerful explosives to demolish bridges causes the transmission of potentially harmful shock waves that can result in internal damage or death of swimbladder fish such as shortnose sturgeons. The effects of blasting on shortnose sturgeons are unknown. For one particular demolition project in the Connecticut River, the NMFS recommended several measures to the minimize the transmission of harmful shock waves, including seasonal restrictions, the use of double-walled cofferdams around each pier to be blasted, and dewatering the outer cofferdams (NMFS 1998c). The use of an air gap to attenuate shock waves is likely to reduce adverse effects to shortnose sturgeons and other swimbladder fish.

The effects of bridge construction and demolition on shortnose sturgeons in Maryland's Chesapeake Bay and its tributaries are unknown. Future projects in the Chesapeake Bay include plans to rebuild the Woodrow Wilson Bridge near Washington, D.C. and to construct a new bridge connecting Montgomery and Fairfax counties (the location has yet to be determined). Both bridge sites are located on the Potomac River. Shortnose sturgeons have been reported in the Potomac River (Skjeveland et al. 2000), but there is no evidence to suggest that sturgeon use either of the bridge sites. The impact of bridge construction, including dredging to create a channel for construction equipment, in areas where shortnose sturgeons may occur needs to be addressed in the planning process. Studies should be conducted to determine sturgeon abundance and distribution within the proposed bridge site and the effects of dredging on sturgeon mortality and habitat. Information on occurrence and potential response to planned activities should be included in environmental impact statements and construction permit applications. The results of these studies may aid in determining the most suitable location for the Montgomery/Fairfax county bridge and future bridge construction projects in the Chesapeake Bay.

Pollution

Agricultural, industrial, and municipal activities contribute contaminants to waterways along the east coast of North America, including the Chesapeake Bay. Aquatic organisms may bioaccumulate environmental contaminants to more than 1,000,000 times the concentrations detected in the water column (Fairey et al. 1997). Contaminants such as toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have serious harmful effects on aquatic organisms, including production of skin tumors, developmental disorders, growth retardation, reproductive impairment, and immunosuppression (see Cooper 1989 for review). Toxins introduced into the water column are generally sequestered in bottom sediments and can be particularly harmful to benthic feeders such as sturgeon. As with other marine species, including marine mammals, heavy metals and organochlorine compounds are known to accumulate in the tissues of sturgeons, but the long term effects are unknown (Alam et al. 2000; Ruelle and Henry 1992; Ruelle and Keenlyne 1993).

Although studies to assess the impacts of pollution on shortnose sturgeons are generally lacking, elevated levels of contaminants in other fish species are linked with reproductive impairment, immunosuppression, reduced egg viability, fin necrosis, retarded growth, developmental abnormalities, and mortality (Cooper 1989; Heath 1995; Longwell et al. 1992; NMFS 1998c). Data suggest that in most cases, the embryo and larval stages are more susceptible to pollution than older life stages (Heath 1995; McKim 1977). However, the same environmental contaminants that cause defective embryos and egg mortality may lead to defects in other periods of fish ontogeny (i.e., juveniles and adults). Some researchers speculate that exposure to PCBs lowers the shortnose sturgeon's resistance to fin rot (Dovel et al. 1992). Analysis of tissues from four shortnose sturgeons collected from a spawning ground in the Hudson River found high concentrations of PCBs, ranging from 22.1 to 997.0 PPM (Dovel 1981). The potential effect of PCBs and other chemicals on shortnose sturgeon health and reproductive success should be investigated in greater detail.

Contaminant studies on related species indicate that concern about the effects of contaminants on short-nose sturgeon populations is warranted. Analysis of tissue from pallid sturgeons in the Missouri River found detectable levels of chlordane, DDE, DDT, and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium. These compounds may affect physiological processes, such as reproduction, and hinder the ability to withstand stress (Ruelle and Keenlyne 1993). Alam et al. (2000) found that concentrations of heavy and trace metals including arsenic, cadmium, cooper, magnesium, and nickel increase in muscle tissue with an increase in body length of juvenile Gulf sturgeons taken from the Suwannee River, Florida. The results indicate that juvenile Gulf sturgeons accumulate metals while in the Suwannee River before migrating to marine waters of the Gulf of Mexico.

The long life span and benthic nature of shortnose sturgeons predispose the species to long-term and repeated exposure to contamination and bioaccumulation of heavy metals and other toxins (Dadswell 1979). In the Connecticut River, coal tar deposits from an abandoned gas work facility contaminated the only known shortnose sturgeon spawning habitat south of the Holyoke dam. The coal tar leachate was believed to be responsible for the observed reproductive failure of sturgeons in the area. A laboratory study to investigate the survival of sturgeon eggs and larvae exposed to PAHs, a byproduct of coal distillation, found that only five percent of the eggs and larvae survived after eighteen days of exposure to coal-tar contaminated sediment collected from the Connecticut River (Kocan et al. 1993). The potential significance of these results is that continued exposure of embryonic or adult shortnose sturgeons to contaminated sediments could lead to a population decline as the result of reproductive impairment. As described above, eggs spawned and fertilized in contaminated habitats are subject to reduced egg viability, increased mortality, and developmental abnormalities. This could have a significant impact on a population that is already depleted as the result of intense overfishing.

Poor water quality resulting from point-source discharges such as municipal wastewater, paper mill effluent, sediment discharges, and power plant cooling waters, may adversely affect fish populations, including the shortnose sturgeon. Discharges contain metals, dioxin, dissolved solids, sediment discharges, phenols, and hydrocarbons that can alter the pH of the receiving water. This can lead to mortality, behavioral modifications, growth retardation, deformations, and reduced egg production and survival in fish (Heath 1995; NMFS 1998c; Zelennikov et al. 1999). Zelennikov et al. (1999) studied the effects of exposure to highly acidic water (pH 4.0-4.8) on reproductive and morphometric development in juvenile Russian sturgeons (*Acipenser gueidenstaefti*). Exposure to low pH water caused a pronounced stress-like effect indicated by a decrease in food consumption and a subsequent decrease in body mass of 13% over a period of 25 days. NMFS (1998c) documented a study in which dioxins and furans were detected in ovarian tissues of shortnose sturgeons collected from a river system in South Carolina. Results indicated that 4 of the 7 fish tissues analyzed contained concentrations of tetrachlorodibenzo-p-dioxin (TCDD) greater than 50ppt, a level which could adversely affect sturgeon fry development.

The Chesapeake Bay receives large quantities of pollutants emitted from industries, agricultural run-off, sewage treatment plants, power plants, and marine transportation (Hardy et al. 1987). These pollutants include metals, such as chromium, copper, lead, and mercury, organic chemicals, such as PAHs, PCBs, and tributylin, and pesticides, such as Atrazine, Metolachlor, and DDT (CBP 1994). The link between contaminants and biological effects on living resources has been a concern in critical Chesapeake Bay habitats (Hall and Alden 1997). Sediments are a major reservoir for metals and organic contaminants because the chemicals adsorb to particles. Disturbances, such as dredging and storms, can cause sediment bound chemicals to be released back into the water column (CBP 1994). Some of the most contaminated sites, based on water column and sediment results, are found in highly industrialized areas including the Baltimore Harbor, Patapsco River, and Back River (CBP 1994; Hall and Alden 1997; McGee et al. 1999). The sediment concentrations of many chemical contaminants in these areas are high enough to adversely affect aquatic organisms (Bieri et al. 1983; CBP 1994; Hale 1988; Rybitski et al. 1995).

Concentrations of chemical contaminants have also been found to be high in areas where shortnose sturgeons have been documented. The results of a sediment study conducted on sections of the Potomac and Anacostia (runs through Washington D.C.) rivers indicated high levels of lead, cadmium, and zinc, as well as PAHs, PCBs, chlordanes, and DDT in many areas (CBP 1993). A striped bass contaminant study conducted by the USFWS from 1984 to 1990 found that concentrations of cadmium, chromium, copper, lead, nickel, and zinc in the Potomac River, Susquehanna River, and C&D canal exceeded water quality standards (CBP 1994). While the effects of contaminants on shortnose sturgeons in the Chesapeake Bay are unknown, results of studies conducted on other species in rivers where sturgeons occur indicate adverse effects. Exposure to ambient water and sediment from the Potomac River caused significant reductions in survival of striped bass larvae and yearlings, sheepshead minnow larvae, amphipods and polychaete worms, growth retardation in grass shrimp and amphipods, and histological abnormalities in several species of fish, including striped bass (CBP 1994). Contaminant studies in the upper Chesapeake Bay, including the C&D canal, found reduced survival of striped bass larvae and histological abnormalities in the gills of yearling striped bass (CBP 1994). Further studies are needed to determine the short- and long-term effects of contaminants on shortnose sturgeons in the Chesapeake Bay.

Dams

Dams have serious consequences for migratory fishes, including the shortnose sturgeon. The construction of dams eliminates or restricts upstream migration of adults and limits the amount of suitable spawning habitat. In addition, dams may alter river flows or temperatures necessary to trigger spawning and migration and cause mortality from turbine entrapment, gas bubble trauma, and columnaris disease (NMFS 1998c; Swanberg 1997). Evidence collected from unobstructed rivers suggests that adult shortnose sturgeons have a behavioral drive to migrate upstream to a spawning area located at about river 200 km or farther (Hall et al. 1991; Kynard 1997; O'Herron et al. 1993). When a dam blocks the spawning migration, females will move as far upstream as possible, then may or may not spawn in the reach just below the dam. A comparison of the maximum upstream spawning locations in rivers throughout the sturgeon's range shows an almost 1:1 relationship between spawning habitats and location of the first dam on a river. Exceptions are rivers with dams located 300 km or farther upstream such as the Savannah, Delaware, and Altamaha rivers (Kynard 1997). A low elevation dam on the Cape Fear River in North Carolina apparently blocks upstream migration of the river's shortnose sturgeon population (Moser and Ross 1995) and the placement of dams on the Peedee, Wateree, Congaree, and Savannah rivers has also precluded sturgeons in South Carolina from historical spawning grounds (Smith 1985).

The construction of a dam may divide a population into an up-river segment, which shows little migratory behavior, and a lower river segment, whose spawning and foraging migrations are blocked by the dam (Kynard 1997; Morita et al. 2000). One of the only truly landlocked populations of shortnose sturgeons can be found in the Connecticut River at the Holyoke Dam (NMFS 1998c). Studies conducted in this

river found that the upper river segment of shortnose sturgeons is the main source of recruitment for the entire population. A spawning run of lower river fish annually migrates upstream to the Holyoke Dam. These fish are ripe and eggs artificially cultured in the lab develop normally (Kynard 1997; Richmond and Kynard 1995). However, intense netting efforts for eggs and embryos below the dam showed that no females spawned in 1993 and 1994, and an estimated 1 in 50 females spawned in 1995 (Kynard 1997). The results were concurrent in all years with successful spawning and production of many eggs and embryos upstream of the Holyoke Dam. Therefore, the successful breeding portion of the Connecticut River shortnose sturgeon population is mainly the upstream adults, of which about 25% (75 individuals) spawn annually. The lower river adults likely contribute little to reproduction, which is probably the result of alterations in habitat (temperature, dissolved oxygen, etc.) caused by the Holyoke Dam.

The construction of dams may restrict population growth and decrease survival rates through the loss of historical spawning habitats and injury or mortality associated with dam operations. In China, hydroelectric power is a major source of energy, with more than 62,000 projects constructed since the 1950s. Almost all of the major rivers systems in China are regulated. The consequences of these dams have been significant for many species of migratory fish. The construction of dams blocked the movements of migratory species including the rare Chinese sturgeon (Acipenser sinensis), Chinese sucker (Myxocyprinus asiaticus) and white sturgeon (Psephurus gladius), to spawning areas. In one river system the number of fish species decreased from 107 to 83 as the result of a dam that interrupted the migration of fish upstream (Zhong and Power 1996). All life stages of fish are susceptible to mortality or serious injury as they pass through the turbines of hydroelectric dams because of sudden current shear stress and water pressure (Isaak and Bjornn 1996; Zhong and Power 1996). In addition to mechanical damage, gas-bubble disease caused by dissolved nitrogen in the water is a source of mortality, as was discovered in fry of four domestic carp species in a regulated river in China (Zhong and Power 1996). The construction of eight mainstream dams in the Snake and Columbia rivers in Washington state resulted in decreased survival rates of anadromous salmon due to delayed migrations, gas bubble disease, mortality associated with turbine passage, and predation (Isaak and Bjornn 1996). In an attempt to decrease mortality associated with passage through the turbines, mitigation activities such as the installation of bypass facilities and submersible traveling screens have been used to divert fish away from turbine intakes. Submersible traveling screens extend into the turbine intakes and redirect a portion of the migrating fish into a bypass system that circumvents the turbines and leads to a collecting area where fish can be either transported to the ocean or discharged back into the river (Isaak and Bjornn 1996). The bypass efficiency rates of these activities vary among location, but have been successful at the Wells Dam (>89%) on the Columbia River, Washington (Skalski et al. 1996).

In addition to primary impacts caused by the blockage of migratory routes, dams also cause changes in the physical and chemical environment that can adversely affect fish species. Zhong and Power (1996) reported lower summer water temperatures below hydroelectric dams in China, which delayed spawning of some species by as much as 20 to 60 days. Late hatching and lower water temperatures reduced the first year growth compared with growth of the same species of fish in an unregulated river. In addition, reduced water velocities and less variable discharges due to dam construction caused abandonment of spawning grounds below several dams. In the Qiantang River an important anadromous fish, the Chinese shad, became extinct as the result of changes to the physical environment caused by the construction of several dams (Zhong and Power 1996).

There are approximately 382 dams, including nine hydroelectric plants, in Maryland that provide essential benefits such as drinking water, flood control, hydroelectric power, recreation, and agricultural irrigation. Many species of anadromous and migratory fish, including American shad, alewife, white perch, and striped bass migrate into the tributaries of the Chesapeake Bay to spawn. The construction of dams blocked migrations to the upper reaches of these rivers and caused a serious decline in the abundance of anadromous fish populations in the Chesapeake Bay. Currently, shortnose sturgeon spawning activity in

the Chesapeake Bay has yet to be identified. However, most dams on the tributaries of the Chesapeake Bay are located too far upstream to interfere with sturgeon spawning migrations and reproduction. Two dams, the Conowingo Dam on the Susquehanna River and the Little Falls Dam on the Potomac River, may be impacting shortnose sturgeons in the Chesapeake Bay. Small numbers of shortnose sturgeons have been documented in both river systems through the sturgeon reward program (Eyler et al. 2000; Skjeveland et al. 2000). The Susquehanna River is regulated extensively in Pennsylvania by the Holtwood, Safe Harbor, and York Haven hydroelectric facilities and also in Maryland by the Conowingo Dam, which is the largest hydroelectric facility in the state. Historically, the Susquehanna River supported large spawning runs of anadromous species such as American shad, herring, and striped bass. However, migrations upstream were eliminated with the construction of the four major hydroelectric plants listed above in the early 1900s (Patty et al. 1999). Several shortnose sturgeons have been documented in the lower Susquehanna River and there are historical records of this species near the mouth of the Susquehanna in the early 1980s (NMFS 1998c; Skjeveland et al. 2000). The Little Falls Dam was built on the Potomac River in 1959 and hinders anadromous fish like shad and herring from moving upstream to spawn. Two shortnose sturgeons have been documented in the Potomac River through the live reward program and there is a historical record of this species in the river dating back to 1876. It is possible that the construction of hydroelectric power plants and dams along the Susquehanna and Potomac rivers disrupted spawning migrations of sturgeons upstream, contributing to the historical decline of this species in the Chesapeake Bay.

Fish passages are being constructed on rivers throughout the United States to enable anadromous fish to bypass these dams and return upriver to their historic spawning habitats. There are several designs of fishway structures including denil, steeppass, vertical slot, pool and weir, and fish lifts. Blockages can also be removed, notched, or breached, particularly if the dam is small or in disrepair. According to NMFS (1998c), sturgeons appear unable to use some fishways (e.g., ladders) but have been passed upstream in fish lifts. For example, the Holyoke Dam fish lifts on the Connecticut River passed 97 fish in twenty-two years (1975 to 1996), with a range of 0 to 16 fish per year (Kynard 1998). Fish passage development in Chesapeake Bay tributaries has been underway since the late 1980s, and includes the four hydroelectric dams on the Susquehanna River (CBP 1997). In 1991 a fish lift was opened at the 90-foot high Conowingo Dam. Fish elevators were opened at Safe Harbor and Holtwood dams in 1997 and a fish ladder was opened at the York Haven hydroelectric facility in 2000. At that time the mainsteam of the Susquehanna River was opened to migratory fish for the first time since the dams were constructed in the early twentieth century (Patty et al. 1999). Another large fish passage project at the Little Falls Dam on the Potomac River was completed in 2000. This fishway combined a series of weirs with a 36-foot wide by 4-foot deep notch in the dam. Completion of this project opened 10 miles of historic spawning habitat for American shad and herring, as well as other species of migratory fish.

Although important habitats for shortnose sturgeons have yet to be identified in the Chesapeake Bay, the use of a fish lift at the Conowingo Dam may benefit this species by providing accessibility to historic spawning grounds. However, the effectiveness of the Little Falls Dam fishway in passing shortnose sturgeons is uncertain. The Maine Department of Natural Resources estimated that the removal of a dam along the Kennebec River would increase the production potential of the shortnose sturgeon population in that river by 11% (NMFS 1996, 1998c). The same may be found to be true for shortnose sturgeons in the Chesapeake Bay.

Dredging

Many rivers and estuaries are periodically dredged to reduce flood events or maintain navigation channels. Important direct effects of dredging activity on aquatic resources include increases in suspended solids, reduced dissolved oxygen levels, mobilization of sediment-associated contaminants, and dredge entrainment of invertebrates, fish, and sea turtles (Chipps et al. 1997; NMFS 1998c). Dredging operations can also destroy important benthic feeding areas, disrupt spawning migrations, and fill spawning habitat

with resuspended sediments. The disposal of dredge spoil may cause destruction and degradation of important habitats for a variety of aquatic organisms. The impacts of dredge disposal, particularly the effects of associated contaminants mobilization, on aquatic organisms have been studied in a variety of habitats. The results suggest that the impacts on the environment are site specific, and may vary greatly depending on the nature of the dredgings and the disposal site (Roberts and Forrest 1999; Smith et al. 1995; Van den Hurk et al. 1997; Winger et al. 2000). Shortnose sturgeon populations can be adversely affected by dredging activities. In particularly, dredges, particularly hopper dredges, can lethally harm sturgeon by entraining fish in dredge dragarms, pipes, or impeller pumps. The NMFS (1998c) reported several incidental takes of sturgeons, including an Atlantic sturgeon in a hopper dredge operating in King's Bay, Georgia, several Atlantic sturgeons in hydraulic and bucket-and-barge operations in Cape Fear River, North Carolina, and five shortnose sturgeons in a hydraulic pipeline dredge operating in the Delaware River. Necropsies conducted on two of the fish killed in the Delaware River found that the skins of both animals were infused with silt, a pattern consistent with fish passing through a hydraulic pipeline dredge. Moser and Ross (1995) conducted a study to document the distribution and movements of adult sturgeons in the lower Cape Fear River. Through the use of sonic tracking they found that Atlantic and shortnose sturgeons occupied regularly dredged areas and were present during dredging operations in the Wilmington Bay. The fish appeared to seek out deep areas and stay in midchannel, behaviors that would put them in the proximity of the dredges. Although Moser and Ross's study did not find any evidence that dredges affected sturgeons in the Cape Fear River, their results indicate that the potential exists for injury and mortality during dredging operations.

The environmental effect of dredging and spoil disposal is a persistent issue in the Chesapeake Bay (see page 50 for additional information). Periodic maintenance dredging of harbors and navigational channels occurs throughout the Chesapeake Bay. One such project involves the maintenance dredging of the Potomac River navigational channel between Washington, D.C. and the mouth of the Wicomico River. The project involves dredging as many as seven sections of the channel with five potential spoil disposal sites in the nearby area. The proposed project raised concerns about the possible impact of dredging on shortnose sturgeon habitat. As mentioned earlier, shortnose sturgeons are found in the Potomac River, but their abundance and distribution are not well documented. The USFWS Maryland Fisheries Resource Office conducted a two-year gill net study to determine the distribution and occurrence of sturgeons within potential dredge material placement sites in the Potomac River (Eyler et al. 2000). Gill nets were placed at five potential placement sites in the river. The sites were sampled for a total of 4,590 hours of fishing effort, during which time no shortnose sturgeons were captured in the gill nets (Eyler et al. 2000). Although the results of this study suggested that the proposed dredging activities would have little, if any, affect on shortnose sturgeons in the Potomac River, other assessments may find that potential dredging sites coincide with important spawning habitat or migratory routes for this species. A similar two-year gillnet study conducted at 19 sites in the upper Chesapeake Bay also had no captures of shortnose sturgeons (Skieveland et al. 2000). However, several sturgeons were captured in commercial fishing gear within the proposed dumping sites during the period of the study, suggesting that the results of the study may be a function of sampling. Further studies should be conducted to more closely determine the distribution of sturgeons in the proposed dredged dumping sites. It is important to make this determination in the planning phases of a potential project, so that proper measures can be taken to avoid or minimize impacts on sturgeons.

Imposing seasonal and area restrictions during sensitive time periods (i.e., spawning, feeding, migration) when sturgeons are most vulnerable to mortality may avoid potential impacts from hopper dredge operation. Documentation of life history may lead to a proposal for a maintenance dredging schedule that is synchronized with the biology of the species. For example, dredging of channel areas in the Hudson River in late spring and early summer (April 15 to June 15) has the potential to adversely impact adult and recently hatched sturgeons. Life history data collected from sturgeons in this river system suggest that dredging would have progressively less impact as summer approaches and sturgeons migrate down-

stream. Therefore, it was recommended that channel dredging in the upper reaches of the river be done in the summer, after the sturgeon have moved out of the area (Dovel et al. 1992). Similar recommendations, including the use of alternative dredge types (i.e., clamshell or hydraulic pipeline) have been made in other river systems where dredging operations were likely to jeopardize a population of shortnose sturgeons (NMFS 1998c).

Due to the documentation of shortnose sturgeons in the Chesapeake Bay through the live reward program, the NMFS has required evaluations of several federal and state dredging projects in the upper Chesapeake Bay and the C&D canal to determine whether these activities are likely to jeopardize sturgeons or adversely impact their habitat. The consultation process includes the preparation of a Biological Assessment by the agency proposing the action to evaluate the potential impacts of dredging and dredge material placement operations on listed species or their habitat. The NMFS reviewed these assessments and formulated a Biological Opinion as to whether the proposed actions would jeopardize the continued existence of shortnose sturgeons or result in the destruction or modification of habitat. To date, the NMFS has determined that the proposed dredging projects in the upper Chesapeake Bay, including the Susquehanna River, Aberdeen Proving Grounds, Northeast River, and Rock Hall Harbor, and in the C&D canal would have little or no impact on shortnose sturgeons (Maryland Environmental Service 2000). The Biological Opinions may also include terms and conditions that the agency proposing the work must follow, including an incidental take statement and the use of NMFS-approved observers to monitor for the presence of shortnose sturgeons and their remains during dredging operations. Shortnose sturgeon observers have been required for at least two dredging projects in Maryland, including a U.S. Army Corps of Engineers maintenance dredging project in the C&D canal and a Maryland DNR fossil oyster shell mining project in the upper Chesapeake Bay. Over a one year period (the time period required by the NMFS) observers aboard dredges used by the Maryland DNR for shell mining documented no shortnose sturgeon mortalities during dredging operations. These consultations, required by Section 7 of the ESA, are important to identify any potential effects of dredging on populations of endangered species such as the shortnose sturgeon. They have also been instrumental in establishing the status of the shortnose sturgeon population in the Chesapeake through the implementation of gill net studies to determine the distribution and occurrence of sturgeons within potential dredge material placement sites.

Power plants and cooling water intake

A variety of aquatic organisms, including shortnose sturgeons, are susceptible to impacts resulting from power plant operations. The construction (excavation, dredging, etc.) and operation of power plants can produce excess levels of turbidity and destroy spawning habitat and prey resources. During the withdrawal of large volumes of water for cooling purposes, fish are killed by impingement on intake screens or during entrainment through the cooling system (Patty et al. 1999; Pawson and Eaton 1999). Monthly samples of fish collected from the cooling water intake screens of the Kingsnorth power station in north Kent, England, recorded 26,372 fish, comprising 41 species, between 1981 and 1983 (Wharfe et al. 1984). Pawson and Easton (1999) estimated that 15% of the available juvenile sea bass population died on the intake screens at this power plant in the autumn and winter of 1987 and 1988.

Documented mortalities of shortnose sturgeons due to power plant operations have occurred in the Delaware, Hudson, Connecticut, Savannah, and Santee rivers (NMFS 1998c). Between 1969 and 1979, 39 shortnose sturgeon were impinged on intake screens at power plants located on the Hudson River (Hoff and Klauda 1979, cited in Dovel et al. 1992). Between October 1982 and September 1983 approximately 160 shortnose sturgeons were estimated to be impinged on intake screens at a steam generating station in Albany, New York (NMFS 1998c). Estimated annual losses of shortnose sturgeons due to impingement at a nuclear generating station in the Delaware River are between 0 and 11 fish (NMFS 1998c). Cooling water withdrawal in the upper portions of rivers near spawning and nursery areas presents a potential risk to the species because the entire spawning population may pass within a few meters of the intake system (Dovel et al. 1992; NMFS 1998c). Eggs and newly hatched larvae, both vulnerable life stages, are at

particular risk for mortality. Plant operations in the lower portions of rivers can also cause mortality in adults during pre- and post-spawning migrations and in larvae during initial movements downstream (Dovel et al. 1992).

The operation of power plants can have extremely detrimental impacts on water quality. Withdrawal and discharge (effluents) of water at power plants can adversely affect surface water quality and the biota that reside in these waters. Reduced water flows resulting from power plant shutdowns can produce anoxic conditions downstream. For example, a power plant near Lake Moutlire, South Carolina, was shut down for several days when large mats of aquatic plants clogged the cooling water intake gates. The combination of decomposing plant material in the canal and the lack of water flow produced a low dissolved oxygen water condition downstream and a subsequent fish kill. According to the South Carolina Wildlife and Marine Resources Department, approximately 20 shortnose sturgeons were killed during the die-off (NMFS 1998c). Low oxygen levels (below 5 parts per million) are known to be stressful to aquatic life, and presumably, sturgeons would be adversely affected by levels below this limit. Jenkins et al. (1993) found that juvenile shortnose sturgeon mortality was high (86%) when exposed to dissolved oxygen levels of 2.5mg/liter. The mortality rate among older sturgeons exposed to the same dissolved oxygen levels was <20%, indicating an increased tolerance for low oxygen levels with age. Sturgeons may also be less tolerant of low dissolved oxygen levels in high ambient water temperatures and exhibit signs of stress or mortality. Atlantic sturgeons reared in hypoxic conditions (2-3mg/liter) at 26° C for 10 days had lower survival (mean=6.3%) and respiration (mean=0.136 mg O₂/g·h) rates than fish reared at 19° C (mean=78.3%, 0.212mg/g·h, respectively) for the same period of time (Secor and Gunderson 1998). All of the dead sturgeon showed a perfusion of blood along the margins of their fins, indicative of oxygen deprivation. Based on these results, the authors suggested that the increased frequency of hypoxia in the Chesapeake Bay due to excess nutrient loading degraded sturgeon nursery habitats and therefore, was detrimental to Atlantic sturgeon growth, survival, and reproduction.

There are sixteen power plants in Maryland; fourteen are located on the Chesapeake Bay or one of its tributaries and draw most of their cooling water from these sources. Over the last two decades several studies have been conducted at 12 major power plants to evaluate the nature and extent of entrainment, impingement, and discharge effects on the aquatic environment, with emphasis on the Chesapeake Bay. The results of these studies indicated that the power plants, taken together, have no identifiable substantive cumulative impact on Maryland's aquatic resources, particularly fish, crabs, plankton, and larvae (MDDNR 1998). One such study involved the proposed renewal of the Calvert Cliffs Nuclear Power Plant (CCNPP) operating license, which lead to a Section 7 consultation with the NMFS and the USFWS in 1997 (Nuclear Regulatory Commission 1999). The purpose of the consultation was to determine whether threatened or endangered species in the area would be adversely affected by the renewal. The shortnose sturgeon was identified as potentially occurring in the vicinity of the CCNPP site. The NMFS concluded that the CCNPP license renewal would not adversely affect the shortnose sturgeons because the cooling water intake system did not lie within the areas normally used by the species. There was no evidence that the thermal effects of the CCNPP cooling water discharge would influence migration to and from river systems nor had a shortnose sturgeon been found impinged on the intake screens during 21 years of monitoring the site. Similar studies should be conducted at all hydroelectric stations in the Chesapeake Bay where sturgeons are present to assess the impact of power generation on shortnose sturgeon mortality.

Individual power plant operation can impact various ecosystem elements in different ways. For example, the Conowingo hydroelectric station on the Susquehanna River controls water levels and flows to downstream aquatic habitats, which can result in changes in dissolved oxygen concentration, water temperature, fish abundance, and food availability (MDDNR 1998; Patty et al. 1999). If water upstream of the dam is released unconditioned during peak electricity demand periods it may have a low dissolved oxygen content, which can cause poor water quality downstream of the dam. During the 1960s, large fish

kills occurred downstream of Conowingo Dam as a result of water containing very low levels of dissolved oxygen being discharged from the generating turbines (MDDNR 1998; Patty et al. 1999). Similar problems have occurred at the Deep Creek hydroelectric station, located on a tributary of the Youghiogheny River, where low dissolved oxygen levels in the station's wastewater discharge have historically limited trout habitat (MDDNR 1998). Efforts to improve the dissolved oxygen levels in water released from hydroelectric dams have included the injection of oxygen into the water column in front of the turbine intakes and turbine venting, in which an intake is constructed to allow air to be entrained into the water passing through a turbine to increase the oxygen content of the water. Turbine venting has proven effective in providing water below the Conowingo Dam that meets Maryland's dissolved oxygen standards (Patty et al. 1999).

Operating hydroelectric facilities in a peaking mode (not continually but in response to peak demand for electricity) also produces unnatural water level fluctuations in aquatic habitats downstream of the dams. Fluctuations in water levels and flow may reduce fish abundance as well as the abundance of important food resources. A five year study of winter flow regimes at the Conowingo Dam showed that an intermittent flow regime did not harm communities of aquatic invertebrates, but that peaking regimes did adversely affect some species (MDDNR 1998). Since these aquatic invertebrates are an important food source for many species of fish in the area, the results lead to a modification to permit an intermittent flow regime throughout the year to protect and enhance aquatic biota downstream of the Conowingo Dam.

Disease

Little information is available on diseases of shortnose sturgeons. Most disease related mortality has been documented in other species of captive reared sturgeons, with very few incidences of disease in wild populations. Among the potential problems hindering the continued development of sturgeon aquaculture and restocking programs are viral diseases that cause mortality in fish at early life stages. One such virus, the white sturgeon iridovirus (WSIV), was first detected in cultured white sturgeons in California in 1988 (LaPatra et al. 1994). Mortality due to this disease can be high and secondary bacterial and protozoal infections are common. Clinical signs of WSIV infections in white sturgeons include anorexia and skin lesions. WSIV is of concern because it is thought to be carried by wild sturgeons and has been shown to cause significant mortalities in juvenile white sturgeons (Hedrick et al. 1990, 1992; LaPatra et al. 1994). Although this disease is confined to the western United States, the potential spread of fish pathogens from one geographic region to another is a possibility. Transfers of carrier fish from the West Coast to the East Coast may pose a significant threat to populations of wild shortnose and Atlantic sturgeons if they are shown to be susceptible to the virus (NMFS & USFWS 1998). To date, susceptibility of shortnose sturgeons to WSIV has not yet been demonstrated. More recently, a new viral pathogen, similar in appearance to WSIV, has been identified in cultured pallid (Scaphirhynchus albus) and shovelnose (S. platorynchus) sturgeons (MacConnell et al. 2001). The shovelnose sturgeon iridovirus (SSIV) was first detected in cultured progeny of wild adults collected from the Missouri River and has the ability to cause debilitating disease and large-scale mortalities. This is thought to be the first documentation of a virus in shovelnose or pallid sturgeons (MacConnell et al. 2001).

While there have been very few reported incidences of disease in shortnose sturgeons in the wild, an epizootic of *Columnaris* sp., a myxobacterium causing ulcerated lesions, occurred at a hatchery in South Carolina (Conroy and Herman 1970; NMFS 1998c). Fungal disease, particularly fin rot, has been documented in wild shortnose sturgeons. Dovel et al. (1992) found that more than 75% (447 of 586 fish) of adult shortnose sturgeons captured for study in the Hudson River had severe incidence of fin rot caused by the fungus *Leptolegnia caudata*. The disease may have lethal and sublethal impacts. The fungus is thought to act as either a primary pathogen that overcomes the fish's immune system or as a secondary pathogen that has invaded after disease resistance is reduced by the presence of a foreign substance. Some researchers have hypothesized that PCBs may lower the sturgeon's resistance to fin rot (Dovel et al. 1992). Fungal infections have been also been found in shortnose sturgeon eggs. Dovel (1981) incubated

eggs in water collected from the Hudson River and in commercial spring water. While a few eggs from the spring water hatched with some fungus present, all of the eggs incubated in water from the Hudson River became infested with fungus and died in less than 48 hours. The fungus that attacked the eggs was not identified, but it could be the same fungus that causes fin rot in older fish. Although fungal infections are typically sublethal, they could contribute to low egg survival, and thus be a factor in the decline of shortnose sturgeon populations along the east coast of North America (Dovel et al. 1992).

A list of known parasites recorded from shortnose sturgeons is given in Table 2 (NMFS 1998c, pg. 40). Parasites are thought to always be present in natural populations and fish are infected by a considerable range of species. Parasite epizootics do not normally occur unless some environmental event alters the equilibrium between the parasite and its host (USFWS and NMFS 1998). The degree of infestation has been reported to be quite low in shortnose sturgeons, with the exception of *Capillospirura* sp. (Dadswell et al. 1984; NMFS 1998c). However, the species does not appear to be harmed by these parasites.

Table 2. List of parasites recorded from the shortnose sturgeon, *Acipenser brevirostrum*.

Group and species	Parasite location	Capture locality	Source
Coelenterata			
Polypodium sp.	Eggs	Saint John River	Hoffman et al. 1974
Platyhelminthes			
Diclybothrium armatum	Gills	Saint John River	Appy and Dadswell 1978
Spirochis sp.	Mesenteric blood vessels	Saint John River	Appy and Dadswell 1978
Nitzschia sturionis	Gills	NY Aquarium	MacCallum (1921)
Nematoda Capillospirura pseudoargumentosus	Gizzard	Saint John River	Appy and Dadswell 1978
Acanthocephala Fessesentis friedi	Spiral valve	Saint John River	Appy and Dadswell 1978
Echinorhynchus attenuatus	??	Woods Hole	Sumner et al. 1911
Hirudinea			
Calliobdella vivida	External	Connecticut River	Smith and Taubert 1980
Piscicola milneri	External	Connecticut River	Smith and Taubert 1980
Piscicola punctata	External	Connecticut River	Smith and Taubert 1980
Arthropoda			
Argulus alosa	External	Saint John River	Appy and Dadswell 1978
Pisces			
Petromyzon marinus	External	Saint John River	Dadswell (pers. obs.)

RECOVERY

The following is a comprehensive list of recommended recovery actions deemed necessary to contribute to the restoration and sustainability of the shortnose sturgeon population in Maryland waters. The objectives are arranged in order of importance, with the most essential actions described first. An implementation schedule summarizing the recovery actions can be found at the end of the recovery narrative. The plan sets out four main objectives: 1) establish cooperative research efforts to determine the population status of shortnose sturgeons in the Chesapeake Bay; 2) formulate a public outreach program to increase awareness of shortnose sturgeons and their status; 3) mitigate or eliminate anthropogenic factors adversely affecting shortnose sturgeons in the Chesapeake Bay; 4) develop a breeding and stocking program for shortnose sturgeons in the Chesapeake Bay. Recommended research, legislative, and management tasks are detailed below. The objectives emphasize the need to obtain data in many areas where current information on shortnose sturgeons is lacking, including population dynamics, distribution, abundance, and genetic origin. Filling in these gaps is essential for the development of effective management

strategies to protect shortnose sturgeons in the Chesapeake Bay. Most importantly, these recovery actions can only be accomplished through the development of partnerships between federal, state, and local agencies, non-governmental organizations, and academic institutions within the Chesapeake Bay region.

RECOVERY OUTLINE

OBJECTIVE 1. Establish and maintain cooperative research efforts to determine the population status of shortnose sturgeons in the Chesapeake Bay.

- 1.1. Coordinate federal, state, and private efforts to implement recovery tasks.
- 1.2. Expand and maintain live sturgeon reward program.
 - 1.2.1 Pursue and secure funding for live reward program.
- 1.3. Determine if genetically distinct population of shortnose sturgeons resides in the Chesapeake Bay.
- 1.4. Determine distribution and abundance of shortnose sturgeons in the Chesapeake Bay.
- 1.5. Determine movement patterns of shortnose sturgeons in the Chesapeake Bay.
- 1.6. Determine growth rates and age of shortnose sturgeons in the Chesapeake Bay.

OBJECTIVE 2. Formulate a public outreach program to increase awareness of shortnose sturgeons and their status in the Chesapeake Bay.

- 2.1. Develop and distribute new educational and outreach materials.
- 2.2. Develop endangered species exhibit at zoos and aquariums.
- 2.3. Establish communication network with commercial watermen in the Chesapeake Bay.

OBJECTIVE 3. Identify and mitigate anthropogenic factors adversely affecting shortnose sturgeons in the Chesapeake Bay.

- 3.1. Study the effects of point and nonpoint pollution on shortnose sturgeons.
- 3.2. Assess and minimize effects of entrainment and impingement in river intakes.
- 3.3. Investigate effects of dredging and spoil disposal.
- 3.4. Reduce by catch of shortnose sturgeons.

OBJECTIVE 4. Develop a breeding and stocking program for shortnose sturgeons in the Chesapeake Bay.

- 4.1. Develop a protocol for breeding, raising and stocking shortnose sturgeons.
- 4.2. Reintroduce shortnose sturgeons into areas in the Chesapeake Bay where they have been extirpated.

RECOVERY NARRATIVE

OBJECTIVE 1. Establish and maintain cooperative research efforts to determine the population status of shortnose sturgeon in the Chesapeake Bay.

1.1. Coordinate federal, state and private efforts to implement recovery tasks.

Many federal and state agencies, organizations, and institutions have worked cooperatively to study shortnose sturgeons in the Chesapeake Bay. The USFWS, Maryland DNR, Chesapeake Bay Foundation, Maryland Port Administration, New York University Medical Center, U.S. Army Corps of Engineers, NMFS, and others have been involved in a variety of projects ranging from genetic studies to the effects of potential dredge material placement on sturgeon habitat in the Potomac River. These cooperative efforts are essential to establish the status of shortnose sturgeons in Maryland's Chesapeake Bay and must be maintained. Collaborators should submit joint proposals for long-term grants (e.g., federal, state, foundation) to conduct shortnose sturgeon projects and establish a

communication network for exchanging research results, highlighting recovery actions, and discussing availability of recent publications. Information posted on email or a newsgroup could be quickly and easily accessible to all involved parties.

1.2. Expand and maintain live sturgeon reward program.

Few sturgeons were reported as bycatch in Chesapeake Bay fisheries during the mid-to late 1900s. However, during the early 1990s anecdotal reports from commercial fishermen indicated that sturgeons were not as rare in the Chesapeake Bay as indicated by bycatch. In 1992, at the request of the Atlantic State Marine Fisheries Commission (ASMFC), the Maryland Fisheries Resources Office of the USFWS started a coast wide cooperative tagging program for sturgeons. The coast wide tagging program has received financial assistance from the Hudson River Foundation and the National Fish and Wildlife Foundation, and now has federal, state, and university cooperators along the Atlantic coast of the United States (Skjeveland et al. 2000). A program to tag sturgeons captured in commercial fisheries in the Chesapeake Bay began on a volunteer basis in 1994. Beginning in 1996, the USFWS, Maryland DNR and Chesapeake Bay Foundation, in cooperation, offered a \$100 reward for live sturgeons captured in Maryland's Chesapeake Bay and its tributaries. In 1997, the program was modified to include a \$25 reward for hatchery-reared sturgeons and a \$100 reward for wild sturgeons. Sturgeons incidentally captured in commercial fishing gear are tagged, weighed, biopsied for genetic analysis, measured, and released. Thirty-nine shortnose sturgeons were reported between 1996 and 2000. The live reward program provides an opportunity to study shortnose sturgeon distribution, movement patterns, mortality, habitat use, bycatch, genetic composition, growth rates, and habitat use in the Chesapeake Bay.

1.2.1. Pursue and secure funding for live reward program.

The reward program is subject to termination at any time due to a shortage of funding. Continuation of the program is vital to understanding the population dynamics of shortnose sturgeons in Maryland waters. Cooperators should seek a more secure funding source to maintain and expand the current live reward program. A Section 6 cooperative agreement with the NMFS should be pursued as a potential long-term, funding source for shortnose sturgeon research, particularly data collected from the live reward program. Other funding sources, including federal, state, and foundation grants, should also be investigated.

1.3. Determine if genetically distinct population of shortnose sturgeons resides in the Chesapeake Bay.

There has been some question as to whether or not the shortnose sturgeons reported in the live reward program are natives to the Chesapeake Bay or if they are from the more abundant Delaware River stock. Collaborative efforts have been established between the USFWS, USGS-BRD, New York University Medical Center, and other organizations to determine the genetic origin of sturgeons in the Chesapeake Bay. These efforts should be maintained and others developed as necessary. Data collected from sonic tags attached to shortnose sturgeons in the upper Chesapeake Bay and Delaware River suggest that they use the C&D Canal, a sea-level canal connecting the two water bodies (Skjeveland et al. 2000). It is possible that the sturgeons documented in the Chesapeake Bay after the sturgeon fishery collapse in the early 1900s are transients from the Delaware River through the canal. Between 1996 and 2000, tissues samples were collected from 28 shortnose

sturgeons captured in the live reward program or collected by researchers. Analysis showed no significant differences between sturgeons from the Delaware River and those captured in the Chesapeake Bay (Grunwald et al. submitted). Genetic analysis should be continued through the live reward program to determine if a genetically distinct population of shortnose sturgeons resides in Maryland's Chesapeake Bay and its tributaries. Samples should be acquired from locations throughout the Bay when possible. Tissue samples were taken from two shortnose sturgeons captured in the Potomac River to determine their genetic origin (Eyler et al. 2000). The results of the genetic analysis are still pending, but may indicate a resident population of shortnose sturgeons in the Potomac River that is genetically distinct from the Delaware River stock.

1.4. Determine distribution and abundance of shortnose sturgeons in the Chesapeake Bay.

The distribution and abundance of shortnose sturgeons in Maryland's Chesapeake Bay and its tributaries are largely unknown. Data collected from the sturgeon reward program and recent gill net studies (Eyler et al. 2000; Skjeveland et al. 2000) have been useful in beginning to understand sturgeon distribution in the Bay, but more directed sampling is needed. Shortnose sturgeons have been captured at various locations (particularly in the upper Bay) throughout the Chesapeake Bay since the implementation of the reward program in 1996. At several of these locations more than one individual was captured. These areas should be targeted and intensely surveyed for adult and large juvenile shortnose sturgeons using gill nets, following the methodology of Skjeveland et al. (2000) and Eyler et al. (2000). Other sampling methods, including drift nets and epibenthic slides, should be used to try and capture small juvenile (larvae and young of the year) fish (Moser et al. 2000). Additional sampling should target areas between the fresh-saline water interface and at the base of the first dam or falls that sturgeons would encounter in the tributaries. Sampling should occur in the early spring to capture pre-spawning adults in the rivers and in the summer to catch fish in likely aggregation areas, such as the freshsaline water interface (Moser et al. 2000).

Bycatch data collected through the live reward program provides valuable information on the location of sturgeons within the Bay and should be continued in the future. Overtime, this mark-and-recapture data can be used to calculate a population size estimate of shortnose sturgeons in the Chesapeake Bay. Telemetry studies, which have been utilized to study movement patterns of shortnose sturgeons in the Chesapeake Bay, should be conducted to identify important habitats (e.g., spawning, feeding sites) within the estuary. Intense sampling should occur throughout the Bay to establish population trends and habitat use for shortnose sturgeons.

1.5. Determine movement patterns of shortnose sturgeons in the Chesapeake Bay.

Studies of shortnose sturgeon movement patterns in the Chesapeake Bay have been preliminarily studied using telemetry. Data collected from sonic tags attached to shortnose sturgeons suggested movement through the C&D canal and in the Upper Chesapeake Bay (Skjeveland et al. 2000). Distances traveled by sturgeons (0 to 5.7 km/day) in the Upper Chesapeake Bay were similar to those reported by Dadswell et al. (1984), but did not appear to follow a specific pattern, such as migrations to spawning grounds. Telemetry efforts should be intensified to further define sturgeon movements and track fish to the river of their origin. Fish captured in other regions of the Chesapeake Bay should be fitted with sonic tags to provide a more complete picture of movement throughout the estuary. Recaptures of fish externally tagged in the live reward program can also provide

information on movement patterns. Locations of recaptured fish can be plotted to estimate distances and direction of movements in the Chesapeake Bay. Movement data collected from telemetry studies and the live reward program may also be important in identifying important habitats including spawning, foraging, and overwintering grounds within the Chesapeake Bay.

1.6. Determine growth rates and age of shortnose sturgeons in the Chesapeake Bay.

Information such as weight and length is collected from each fish reported to the sturgeon reward program. Based on this data, a length-weight relationship has been established for sturgeons in the upper Chesapeake Bay (Skjeveland et al. 2000). Efforts should continue to establish similar relationships for sturgeons throughout Bay for comparison with other river systems. Morphometric data collected from recaptures of fish tagged in the live reward program can and has been used to determine growth rates of sturgeons in the Chesapeake Bay. This data should continue to be collected through the sturgeon reward program. In the future, growth rates could be used to evaluate the success of a restoration project in which hatchery-reared shortnose sturgeons are released into the Chesapeake Bay. Samples of pectoral spines taken from shortnose sturgeons captured in the live reward program may be analyzed to determine the age structure of the population, as has been in done in Atlantic sturgeons in the Chesapeake Bay (Skjeveland et al. 2000). However, this would require the acquisition of the appropriate permits from the NMFS. In addition, the removal of pectoral fin rays for aging studies is somewhat controversial and alternative methods should be investigated. Regardless of the method, sampling should occur in all size classes if possible. Analysis of the age structure can be used to assess the stability of the sturgeon population in the Chesapeake Bay (NMFS 1998c).

OBJECTIVE 2. Formulate a public outreach program to increase awareness of shortnose sturgeons and their status.

Shortnose sturgeon conservation requires long-term public awareness and support. The public must be informed of the issues and laws, particularly when conservation measures conflict with human activities such as commercial fisheries, construction of dams, and dredging. Public outreach programs should be carried out by both government and non-governmental agencies and organizations in Maryland to achieve a level of awareness and support for shortnose sturgeon conservation.

2.1. Develop and distribute new educational and outreach materials.

Agencies and organizations such as the Maryland DNR, USFWS, National Aquarium in Baltimore, and Chesapeake Bay Program should work cooperatively to generate public interest in shortnose sturgeon issues and recovery. Feature stories on the current plight of sturgeons in the Chesapeake Bay should be developed in collaboration with the media. Professionally produced public service announcements for radio and TV would be effective for informing the public about sturgeon biology, the factors affecting their population, and current research efforts. The announcements could also include the 1-800 number to report live sturgeons captured in commercial fisheries. Articles, posters, videotapes, educational curricula, and pamphlets should be developed and distributed to increase public knowledge of shortnose sturgeons and their unique and complex life history. The information included in these materials could include a species description, listing status, range, susceptibility to human factors, and the live reward program 1-800 number to report incidental captures or sightings. These materials could be made available over the internet or via mail and proceeds could go towards sturgeon research.

2.2. Develop endangered species exhibit at zoos and aquariums.

Cultured shortnose sturgeons should be placed in zoos and aquariums to increase public awareness of this species and its plight in the Chesapeake Bay and throughout its range. Exhibits at the NAIB and the Baltimore Zoo could contain information such as shortnose sturgeons vs. Atlantic sturgeons at all life stages (e.g., identifiable features of each), historical distribution, abundance, and decline of the population (particularly in the Chesapeake Bay), listing status, present knowledge of the sturgeon population in the Bay, and current research efforts. A donation box could be displayed to collect funds to support the live reward program or the development of outreach materials.

2.3. Establish communication network with commercial watermen in the Chesapeake Bay.

The success of the live reward program is dependent upon the cooperation of commercial watermen in the Chesapeake Bay. Watermen report live sturgeons incidentally captured in fishing gear to the USFWS in return for financial compensation. The live reward program was announced by postcard to all licensed watermen in 1997 and is advertised on the USFWS and Maryland DNR websites (www.fws.gov/r5cbfo/Ecoteam/ecosturg.htm; www.dnr.state.md.us). Regular updates of recovery efforts, including the results of data collected in the live reward program, should be made available to commercial watermen via the internet and newsletters (e.g., Watermen's Gazette). Postcards announcing the live reward program should be sent to newly licensed commercial watermen to solicit help with the project. Regular correspondence with commercial watermen will generate and maintain interest in the live reward program, which is key to determining the status of shortnose sturgeons in Maryland's Chesapeake Bay.

OBJECTIVE 3. Identify and mitigate anthropogenic factors adversely affecting shortnose sturgeons in the Chesapeake Bay.

Anthropogenic factors can adversely affect shortnose sturgeons by modifying or destroying important habitats and causing mortality. Activities such as dredging, bridge construction, power plant operation, and dam operation and maintenance directly and indirectly affect sturgeons (see Factors Affecting Recovery). These activities should be mitigated or eliminated when possible. Researching all of these impacts will refine and increase the number of mitigation alternatives available to fisheries managers.

3.1. Study the effects of point and nonpoint pollution on shortnose sturgeons in the Chesapeake Bay.

The levels and effects of contaminants on shortnose sturgeons in the Chesapeake Bay are largely unknown and need to be evaluated. Shortnose sturgeon tissues, food items, and sediment and water samples from potentially important habitats should be analyzed to assess the degree of contaminant loading. The effects of contaminants on sturgeon growth, reproduction, survival, and disease resistance can be studied using hatchery-raised fish. Additionally, the specific levels at which contaminants become harmful to sturgeons should be identified. Many regions of the Chesapeake Bay are susceptible to hypoxic conditions. Cultured sturgeon should be used to determine the species' tolerance to low dissolved oxygen concentrations under a variety of temperature and salinity conditions found in the Chesapeake Bay. The sublethal and lethal effects of hypoxia on shortnose sturgeons should also be assessed in the laboratory. Under auspices of the Chesapeake Bay Program, major habitat improvement projects are underway in the Chesapeake Bay that will positively affect sturgeons. Sources of point and nonpoint source pollution in the Chesapeake Bay have been identified and steps have been taken to reduce pollution load-

ing to relieve anoxic conditions and improve water quality (1987 Chesapeake Bay Agreement). These efforts to clean up the watershed will contribute to the recovery and sustainability of living resources, including the shortnose sturgeon.

3.2. Assess and minimize effects of entrainment and impingement in river intakes in the Chesapeake Bay.

The occurrence and effect of entrainment and impingement of shortnose sturgeons in river intakes including power plant cooling water intake systems, hydroelectric turbines, and dredges (see 3.3), in the Chesapeake Bay should be assessed. Studies similar to the Calvert Cliffs Nuclear Power Plant Section 7 consultation should be conducted in areas near power plants where shortnose sturgeons have been documented. These power plants could be periodically monitored to assess sturgeon mortality and impingement on intake screens. Mortality resulting from turbine passage should be monitored at hydroelectric facilities located on rivers where shortnose sturgeons have been documented. For example, the Conowingo Dam is situated on the Susquehanna River, where shortnose sturgeons have been reported in the live reward program. Therefore, this site should be monitored. Efforts to obtain scientific information should be maximized by examining all dead fish to collect information on life history and status of the species. If necessary, the effects of entrainment and impingement can be mitigated by requiring screening of intake water systems (which are in place in most power plants in Maryland) or limiting the location, duration, or volume of water withdrawals.

3.3. Investigate effects of dredging and spoil disposal on shortnose sturgeons in the Chesapeake Bay.

Dredges have been documented as a source of mortality for shortnose sturgeons in river systems along the East Coast of the United States (NMFS 1998c). Sampling for the presence of shortnose sturgeons is often required when activities that could jeopardize the existence of the species are proposed in an area where their status is unknown. For example, gill net studies have been conducted to determine the effects of potential dredge disposal sites on shortnose sturgeon habitat in the Chesapeake Bay (Eyler et al. 2000; Skjeveland et al. 2000). Future studies mandated by the NMFS (through Section 7 of the ESA) will aid in determining if sturgeon use areas of proposed dredge and fill operations in the Chesapeake Bay. Distribution data will help to establish which proposed spoil areas may coincide with sturgeon habitat. The continued use of observers to monitor dredge operations is important to ensure that shortnose sturgeon mortality does not exceed the permitted incidental take issued by the NMFS.

3.4. Reduce by catch of shortnose sturgeons in the Chesapeake Bay.

Many fisheries that incidentally capture shortnose sturgeons in the Chesapeake Bay have been identified through the sturgeon reward program. Estimates of mortality resulting from incidental capture should be obtained and sub-lethal effects of capture and release (e.g., hooking, handling) should be assessed for each fishery. Based on these results, guidelines can be developed to reduce bycatch mortality and injury, including recommendations for watermen on proper handling procedures to reduce stress and mortality. A fishery could be regulated to minimize its impact on sturgeon mortality if absolutely necessary. If sturgeon spawning grounds and habitat are identified in the Chesapeake Bay, seasonal fishing restrictions could be placed on those sites to reduce the likelihood of an incidental capture.

OBJECTIVE 4. Develop a breeding and stocking program for shortnose sturgeons in the Chesapeake Bay.

Artificial propagation of shortnose sturgeons for use in restoration of extirpated populations or recovery of severely depleted wild populations may become a tool for recovery of this species in the future. According to the NMFS (1998c), in some river systems shortnose sturgeons may be so rare that a population is functionally extirpated. This may in fact be the case for the Chesapeake Bay. If rigorous and thorough sampling indicates that a population of sturgeons historically occurred in the estuary, then hatchery-reared sturgeons may be reintroduced if sufficient habitat is available for all life stages and if the NMFS determines that reintroduction is appropriate.

4.1. Develop a protocol for breeding, raising, and stocking shortnose sturgeons.

A breeding and stocking protocol is needed to insure that the best possible practices are used in the production of shortnose sturgeons in a hatchery, when and if NMFS decides that stocking is necessary for recovery purposes. The protocol must be consistent with the NMFS policy on artificial propagation of threatened and endangered species under the ESA. Generally, procedures should follow those designed for the propagation of Atlantic sturgeons, which are outlined in the "Breeding and Stocking Protocol for Cultured Atlantic Sturgeon" (ASFMC 1996). The protocol should identify appropriate parameters to be followed when culturing sturgeons, including techniques for obtaining gametes, fertilizing and incubating eggs, optimal rearing temperatures, appropriate population size to ensure genetic diversity, diet, feed rations, and stocking densities. Culturing practices should duplicate known natural conditions when possible.

4.2. Reintroduce shortnose sturgeons into areas in the Chesapeake Bay where they have been extirpated.

Continued efforts to determine the population dynamics, distribution, and abundance of shortnose sturgeons in the Chesapeake Bay may suggest that reintroduction of cultured sturgeons is a necessary and viable option for the recovery of the Bay's population. If the NMFS determines that reintroduction is appropriate, fish should be propagated following a protocol developed for the species (see 4.1.). If broodstock native to the Chesapeake Bay are not available for artificial culturing, a donor stock that closely matches the life history and genetics of sturgeons in the Bay will need to be selected. All stocked fish should be tagged to monitor movement patterns, survival, foraging, and growth to evaluate the success of population restoration efforts.

Artificially cultured Atlantic sturgeons have been successfully raised and released in the Chesapeake Bay. In July 1996, 3,000 tagged yearling Atlantic sturgeons of Hudson River origin were stocked into the Nanticoke River, a tributary of the Chesapeake Bay that once supported spawning sturgeons. Recaptures of tagged Atlantic sturgeon in the live reward program suggest that growth and survival of the stocked sturgeons are excellent, indicating promising potential for hatchery restoration efforts (USFWS & NMFS 1998). Current plans include obtaining wild sturgeons from the Chesapeake Bay to use as broodstock for a sturgeon stocking program in Maryland. These fish are being collected and added to the current population of captive reared fish to ensure suitable genetic diversity for future generations of cultured fish. A similar captive breeding program, based on guidelines established by the NMFS and the success of the Atlantic sturgeon stocking program in Maryland, could be developed to restore shortnose sturgeons to the Chesapeake Bay.

Table 3. Implementation Schedule for Shortnose Sturgeon Recovery Tasks

Task Name	Priority	Duration	Cost Estimates					Comments
			FY1	FY2	FY3	FY4	FY5	
1.1. Coordinate federal, state and private efforts to implement recovery tasks	1	ongoing	\$0	\$0	\$0	\$0	\$0	
1.2.1. Pursue and secure funding for live reward program	1	ongoing	\$8,000	\$8,000	\$8,000	\$8,000	\$8,000	
1.3. Determine if genetically distinct population of shortnose sturgeons resides in the Chesapeake Bay	1	ongoing	\$10,000?	\$10,000?	\$10,000?	\$10,000?	\$10,000?	cost will depend on number of samples
1.4. Determine distribution and abundance	1	ongoing	\$70,000	\$70,000	\$70,000	\$70,000	\$70,000	directed sampling & live reward program
1.5. Determine movement patterns	1			\$10,000	\$10,000	\$10,000	\$10,000	directed sampling & live reward program
1.6. Determine growth rates and age	1	ongoing		\$5,000	\$5,000	\$5,000	\$5,000	directed sampling & live reward program
2.1. Develop new educational and outreach materials	1	continuous	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	publication costs
2.2. Develop endangered species exhibit at zoos and aquariums	2	continuous	\$30,000	\$10,000	\$10,000	\$10,000	\$10,000	gear modifications, etc.
2.3. Establish communication network with commercial watermen	2	continuous	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	publication costs
3.1. Study the effects of point and nonpoint pollution	2	5 yrs.	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	
3.2. Assess mortality of entrainment and impingement	2	2 yrs.	\$60,000	\$60,000	\$40,000	\$40,000	\$40,000	with annual monitoring
3.3. Investigate effects of dredging and spoil disposal	2	ongoing						ESA section 7 consultations, costs depend on proposed activities
3.4. Reduce bycatch of shortnose sturgeons	2	ongoing	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000	
4.1. Develop a protocol for breeding, raising, and stocking shortnose sturgeons	2	as warranted by NMFS						will be conducted by NMFS
4.2. Reintroduce shortnose sturgeons	2	as warranted by NMFS						will be conducted by NMFS

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APPENDIX I. Maps of Marine Mammal and Sea Turtle Strandings in Maryland, 1991-2000

